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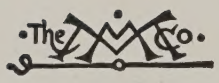

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STUDIES IN THE LITERATURE OF NATURAL SCIENCE

BY

JULIAN M. DRACHMAN

NEW YORK

THE MACMILLAN COMPANY

1930

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Growth of Science

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TO
THE FIRST PH. D.
OF MY ACQUAINTANCE—
MY FATHER

ACKNOWLEDGMENT

These studies are the outgrowth of a short essay on "Huxley as a Writer," which was suggested by Professor Ashley Horace Thorndike, of Columbia University. For timely counsel, encouragement, suggestion, and assistance freely given at every stage in the preparation of this book, sincerest appreciation is given to Professor Thorndike.

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CONTENTS

CHAPTER		PAGE
I.	Introductory. What, If Anything, Is Scientific Literature?	3
	PART I	
	THE FIRST THIRTY YEARS (The Catastrophic War)	
II.	Boundless Providence or Limitless Change	35
III.	The Events of 1830	43
IV.	Other Men and Later Years	51
	PART II	
	THEORIES OF EVOLUTION	
V.	To the Grand Century	63
VI.	Darwin the First	74
VII.	French and German Theorists	93
VIII.	A Few Eccentrics—The Great Discussion Again	110
IX.	"Vestiges of Creation" and "Footprints of the Creator"	121
X.	Anatomist Against Philosopher (Owen and Spencer)	141
	PART III	
	DARWIN AND OTHER VICTORIANS	
XI.	Pattern of an Idler	159
XII.	The "Beagle" Adventure	167

CHAPTER		PAGE
XIII.	Species Become an Obsession	183
XIV.	The Great Book—Friends and a Rival	196
XV.	Arms Clash on Parnassus	215
XVI.	Bringing Up the Rear	249
XVII.	"Hobby-horses" of a Retired Naturalist	263
XVIII.	Gladiator-General and Maid-of-all-Work	281
XIX.	Followers	311

PART IV

CERTAIN SPECIAL TYPES

XX.	The Great Synthesists	333
XXI.	Popularizers of Science	372
XXII.	Natural History Essays and Journals of Travel	394
XXIII.	Unity or Plurality? Is Life Limited to the Earth?	416
	Questionnaire on the Literature of Science	435
	Bibliography	441
	Index	479

ILLUSTRATIONS

PAGE

Sir Charles Lyell 48

Hugh Miller 136

Down House 200

"Natural Selection." A Cartoon of Charles Darwin . . 264

Thomas Henry Huxley 294

John Tyndall 386

STUDIES IN THE LITERATURE OF NATURAL SCIENCE

There is only one theme with blood and life in it for the literature of our century. Plots that grow from it are vigorous and fecund, fruiting in stories that arouse attention and change the mind. Poetry inspired by it does more than please, it stirs: poetry unaware of it is likely to be jingle or an intellectual trick. . . . Reduced to its lowest terms, it is the effect of machinery on man.

Henry Seidel Canby.

I wonder in what witches' cauldron of folly the absurdity was brewed that poetry and science are enemies.

Colonel Sir Ronald Ross.

There is no light in souls in which there is no warmth.

Joubert.

Every edifice built upon abstract ideas is a temple raised for the worship of error.

Buffon.

Nature does not reveal all her secrets at once. We imagine we are initiated into her mysteries when we are as yet but hanging around her outer courts.

Seneca.

The scientific investigation of nature strives to recognize the universal in each particular, so that at last it may come nearer to the source of all things.

Goethe.

Do not these passages and *thousands like them* make one suspect there is a very close resemblance between art and science, so close that we might say that art is science, only more scientific?

Rebecca West.

No man ever read a book of science from pure inclination.

Samuel Johnson.

CHAPTER I

INTRODUCTORY

WHAT, IF ANYTHING, IS SCIENTIFIC LITERATURE?

It was the gracious practice of our ancestors to begin every book by inditing an apology or an argument. The very Fathers of the American republic would not launch into a rebellion without being moved by a decent regard for the opinion of mankind into explaining why they were taking so radical a step—nor did they begin to explain without giving reason for the explanation.

Today it is, if possible, even more binding upon one who wishes to add another book to the immense débris of paper and print already existing to tell why he does so or to show unmistakably what useful purpose his book may serve. In short, what reason is there for a discussion of the literature of science?

Most persons who have never given any especial thought to the question would, I fancy, respond like a certain medical doctor, who, upon being told the subject of this book, broke into a sudden, frank outburst of laughter. More plainly than in words, he declared that there is no such thing as a literature of science, that there cannot be any such thing, because the two parts of the partnership are elementally different in kind, that literature and science are as unfit yoke-fellows as, for instance, an ox and the aurora borealis. He had read many scientific books, medical texts and treatises, professional journals, tabulations and classifications, reports of experi-

ments told in serviceable but wearying detail. He had read, too, some novels and perhaps could recall a dash or two of poetry in early youth; and his sense of the absurdity of joining these two discordant elements is not surprising.

By limiting the discussion to pure theory, it would be possible to get up rather a good case for either side, or for both sides, of the argument. It is not hard to draw up a formidable list of vital differences, and to conclude from such a list that the two are incompatible. So far as science is a field, it deals primarily with matter and physical force, whereas literature deals first and foremost with human beings and the forces of individual and social life. So far as science is a method, it attempts to collect all available facts and—sometimes—to organize them into vast systems under abstract formulæ; so far as literature is a method, it seeks to interpret the individual, the typical; sometimes it portrays general laws as working out in individual lives, but has little concern over the formulation of the laws themselves. Science is primarily concerned with truth, literature with beauty, science with the acquisition of knowledge, literature with the expression of emotion.

So far, mere theory. Now all theory suffers from one fundamental weakness: in order to present a coherent account of the situation discussed, it voluntarily chooses to leave certain facts and certain factors out of sight. This it must do, or be so cumbered with special phases, exceptions, hedgings, and particular viewpoints as to be quite incomprehensible. Theory is simplification and therefore partial falsification. Life and nature do not present an album of flat silhouettes, a world of contrasting black and white, but an infinitely graded series of tints, stretching from an almost black violet at one end to a red at the other that is likewise almost black. To carry the analogy further, analysis of the spectrum

teaches us that there are even vibrations of "dark light" beyond both extremes.

I think it may be found, upon thoughtful study, that the sharp contrast which is so often assumed to sever literature and science is really as misleading a standard as the proverbial contrast between white and black. Some books there are at the violet extreme of utterly non-human scientific presentation: tables of statistics, uninterpreted computations and measurements, classifications—the telephone-books and time-tables of scientific thought. There are books, too, at the scarlet end of pure emotional expression or meaningless melodiousness—the barbaric yawp, the dadaist medley, or the lyric that neither portrays character nor hints at the writer's philosophy, that conveys no lesson, paints no significant picture, interprets nothing. But all the intervening stages are crowded with volumes that present both science and art, both knowledge and emotion intermingled, blended together in various proportions and with various degrees of assimilation. A great many books are works of more or less science as well as more or less literature—or are they?

It is to discover a consistent answer to this question that the present study is being made, to convey that answer and several other related answers that this book is set before the reading public. There must be a place for it; if many people have not asked themselves this very question, it seems likely that they will do so soon. Useful reading matter—often on phases of pure science or applied science—is becoming more and more widely diffused. Among the best sellers of recent years have been such books as Dr. De Kruif's "Microbe Hunters," Dr. Dorsey's "Why We Behave Like Human Beings," Professor Eddington's "The Nature of the Physical World," Professor Slosson's ultra-modern series from "Creative Chemistry" to "Keeping Up With Science," the writings

of H. G. Wells and Professor James Harvey Robinson and that coöperative compendium under Professor John Arthur Thomson's editorship, "The Outline of Science." "Non-fiction is of primary interest to the book-buying public today," a recent newspaper item quotes a Southern bookseller as saying. The interview continues: "Semi-scientific volumes of psychological trend have grown enormously in popularity during the past few years, which is probably due to the fortunate combination of certain literary ability with scientific knowledge." This is just one of many such dicta, not in any sense an authoritative statement, but significant as coming from that gauge of public taste—the trade.[1]

The scientist can no longer isolate himself in the laboratory, his equivalent of the ivory tower, and tell the mob to mind their own affairs and not meddle with his specialty. They will storm in to gape at his retorts and centrifuges whether he invites them or not. But obviously they will not all go through the long apprenticeship needed to become specialists. We cannot all become specialists, and both life and science would suffer if we did. What we want is to find our science in books—in books that we can learn to read without spending lifetimes in the mere learning of an alphabet, books that contain more for us than the "frost of fact that gives correctly stated death to all that lives." We want to understand nature and our own place therein. To understand nature alone is perhaps the major task of science; to chronicle man's adventure from birth to death is perhaps the major task of literature. The present and the coming generations

[1] See "The Coöperative Crier" for an article by Stuart Chase suggesting that advertisers ought to make more use of "scientific appeal" because "The Outline of This" and "The Story of That" have roused Mr. Averageman's interest in anything that looks scientific. . . . Some advertisers have fastened upon the new words as magical phrases with which to enchant the consumer.

See also W. S. Gray, "Reading Interests and Habits of Adults," Macmillan, 1929.

can never grasp the significance of much in present life and civilization until they know something of science, wherefore something of scientific knowledge is and will be increasingly indispensable to literature. But science cannot be given to man, except the few specialists, save by allowing for the complex of tastes and gifts and perversities that man is, by a portrayal in which science may be protagonist but man is at least the background. As Professor Philip Marshall Hicks has it, "Man is interested in nature just in the proportion that he sees himself mirrored there." Thoreau, less objectively, more idealistically, declared "Nature must be viewed humanly to be viewed at all. . . . A fact must be the vehicle of some humanity in order to interest us. . . . A man has not seen a thing who has not felt it."

Orthodox science is supposed to have nothing to do with feeling. If feeling is such as to warp one's vision, the obvious rightness of this old doctrine needs no further defense. But a study of the lives of the greatest scientists —from Archimedes rushing naked through the streets shouting "Eureka, I have it!" down to date—shows that feeling has always played more than a minor part in discovery. Will a similar study show feeling to have been equally important in the writing of scientific books? If it does, I think we may claim that there is a literature of science.

For this reason it seems preferable to use the new term "humanized science" [2] in place of the older "popularized science." Though both words ultimately refer to man, which is to be expected, "popular" suggests the populace and therefore an ignorant multitude. Popularized science suggests science from which all the "hard parts" have been removed, to which sensational, perhaps misleading, features have been added, science pointed to with admiring "ah's" and "oh's," lapped in sentimental gibberish,

[2] See J. H. Robinson, "The Humanization of Knowledge."

and poor in real content. Of course, not all popular science is so bad as that, and some of it is masterly; but that is what the name suggests, often justly. It is better to look for a new term, and "humanized" means only that man, always chiefly interested in himself, can find a contact between that self and what he is studying.

This point must be stressed here because an easy heresy leads to the guess that the literature of science is quite the same thing as popular science. If it were, it would be a field greatly limited. But if scientific literature be taken to mean all writing upon scientific subjects that possesses some sort of fairly general human interest, not separated from its scientific theme but integrated with it, the field becomes vastly greater and infinitely more important. Works of popularized science must almost all be secondary, reheatings, softenings of what has before been given by a discoverer to his peers; they are likely to suffer a downward revision after first being conceived on a higher mental level. Works of scientific literature, on the other hand, may be the original, epoch-making pronouncements of the first discoverers themselves. Their appeal to the humanity of man the thinker, instead of to the thinker in the abstract, does not mean an appeal to the ignorant.

Why, then, shall we limit the field in any way? There is a widespread use of the name "literature" to cover anything in print. We hear of advertising literature, campaign literature, propagandist literature, and so on. From that point of view, one might speak of scientific literature, meaning thereby any printed matter dealing with science.

There is much to be said for such a view. It would remove at a stroke the embarrassment of having to judge whether any particular book is or is not that elusive wraith, literature, whether it has or lacks literary qualities which the author in all probability thought nothing about.

Literature includes much more than mere fine writing, and how much more who shall say? But though it is impossible to draw a line with any distinctness, we must assume some invisible equator running about the middle of the world and separating two hemispheres of scientific writing. Professor Edith Rickert, in "New Methods for the Study of Literature," defines literature as "the interpretation of life through the medium of words," and adds, "there is an obvious distinction of purpose to be made between words used to record observations of fact, either as an end in themselves or as a basis for generalizations and laws, and words used as a means of transferring experience. Gossip is nearer to literature than is a ship's log." This is Professor Rickert's way of saying that science is not literature. But she goes on thus: "The truth is that all records of fact are subject to incursions of realized experience, which lift them for the moment into literature." Suppose, then, that a certain writer upon scientific subjects allowed frequent incursions of realized experience, might we not consider much of his writing to belong to the field of literature? In the works of another, there might be few such oases; his readers might be limited to such as could find mental food in his substance only, with never a trace of that human quality which comes from the transferring of experience. Perhaps it would be futile to maintain that such books constitute literature.

Literature, being the product of an art, may be expected to give pleasure. Now, this supplies us with a purely subjective standard that is none too dependable. One man will find pleasure in the very thing which will be most painful to another. The trained specialist may thoroughly enjoy a treatment, however wordy and unskillful, of a subject that he happens to be interested in, much as an heir is happy to read the telegram informing him that a fortune is to be his—and this regardless of the

slovenly wording of that message. Literature must be able to give some kind of intellectual satisfaction even to those who have no utilitarian interest at stake in its content. It gives delight or joy because it touches that fortune to which we are all heirs equally, the treasure of human experience.

Science has been growing more and more into a part of human experience. Essentially, science is everybody's business, not so much because we depend upon its products for our food and transportation as because its revelations are swiftly and surely changing our picture of the universe. Some of its applications are full of interest, but what fires the imagination is something else; man has ever been surrounded by strange vacua of mystery, to penetrate which has been one of his deepest and noblest longings, and this science is helping him to achieve. Pure science, then, is fraught with messages for every thinking person and accordingly is an apt field for humanization.

So far, our reasoning leads only to an appeal to scientific writers to set their thoughts into humanly significant form, to write with the reader, rather than the logic of the material, in mind. Complaints against their writing are common enough upon the part of reviewers as well as of plain readers. For instance, a recent review [8] deplores "a practice which is unfortunately very common among American scientists; namely, the use of such complex phraseology that even the scientist spends an undue amount of energy in deciphering the meaning." Anyone who reads many such reviews finds innumerable similar complaints, and anyone who reads scientific works indiscriminately is bound to utter them himself. Desirable as it may be for all scientific writers to be literary artists, in the nature of things that consummation is impossible.

Some writers may feel that it simply cannot be done,

[8] Raymond Pearl, "The Rate of Living," review by Ellsworth Huntington in *Saturday Review of Literature*, April 28, 1928.

that there are so many and such serious complications in the subject as to make a literary treatment impossible. That two opinions on this point are possible is shown by such observations as the following. Mr. Bertrand Russell, in discussing the newest physical and mathematical theories, declares that [4] "this aspect of their work is only accidentally involved in mathematical technicalities, and can with a little trouble be so presented that intelligent laymen, at any rate the younger of them, can understand it and appreciate its importance." And again, "In the nineteenth century the most sensational piece of science was Darwinian evolution, which was easily intelligible to any educated man."

A reading of scientific reviews will show that in the opinion of critics the task of treating scientific matters in a literary manner is a possible and worth-while one. The praise given to well-written books offers one argument against the scientist's fear of being too "popular" or his assumption that good science cannot mix with literature.

If it could be shown that the writers of scientific classics, the great original discoverers whose names are remembered for real, substantive achievement, produced what in some cases were works of literary art, that might be a more convincing argument still. If Darwin and Newton, Lamarck, Lyell, Faraday, Davy, Herschell—of whose claim to discovery and knowledge there can be no dispute—were more or less skilled literary craftsmen who made their books the vehicles of human experience as well as of facts and principles, then surely no man need feel that good writing is unworthy of his serious work. For this reason it has seemed desirable to prepare a careful, detailed study of the *corpus* of scientific literature, viewing it, for the first time, chiefly as literature. His-

[4] All from the *Saturday Review of Literature*, "Physics and Metaphysics," May 26, 1928. See also Arthur Stanley Eddington, "Science and the Unseen World," Macmillan, 1929.

tories of science have been written often enough, and many of them refer more or less casually to epoch-making books, but it is rare to find a detailed, or even an attentive, discussion of them *as books*. We read that in 1800 Lamarck first enunciated his theory of transformism; we are not told whether the enunciation was a communication read before a learned society, an essay or book full of charm and force, an oral lecture so confused as barely to transfer its message to the hearers, or a diagram entered in a notebook. Is it not worth while to retell the history of some branch or period of science, shifting the emphasis from pure content to the literary quality of the books in which the results of investigation are contained? The proportions will be quite different; comparatively unknown writers will be dealt with at length, not because of the importance of their discoveries but because of their skill or gift in presentation. Some of the greatest innovators may be passed by without comment, if their writing does not shed light *as writing*. So, too, the internationalism that is characteristic of almost all advance in the subject-matter of science may give way in part before the nationalism to which language habits limit literary progress. Just as histories of science are often vague about the form in which discoveries are couched, they are frequently inexact or erroneous in citing the titles of great scientific books. To be sure, many such books are burdened with cumbrous, tasteless titles, for which some substitution supplies a graceful nickname. However the practice of calling books by something other than their true names makes it difficult for the reader to obtain the book he wants or to be sure that what he has found is the right one. A history of the literature of science should seek the actual given names of the classics of its province and at least mention them.

Furthermore, many a scientific writer has given his thought to the world repeatedly. Sometimes the sole

growth from the first to the last edition has been in regard to form; in other words, a literary growth. In other cases new facts have been discovered or longer reflection has supplied a maturer view. It is significant to the literary student of these works to follow this growth, especially if it has been along purely literary lines. Such a genetic study of the gestation of a book in the mind of its scientific parent is an indication of the value of literary quality in scientific writing as well as a means of judging what literary qualities are desirable in such works. If Huxley found it worth the effort to rewrite a single essay five or six times before giving it to the world, the scientific writer of today may do well to find out what qualities he was trying to give that essay and how he obtained the effects sought.

Such a study of the body of scientific literature can be of even greater value to the reader. He may be unaware that there is any good scientific literature apart from a few popularizations, for which he may have scant respect. If he can be shown that there is a large, respectable, consistent mass of good science so presented as to constitute good literature, which he can, with reasonable effort, train himself to appreciate and enjoy, he will seize the opportunity to enter this new quarter of human experience. The scope of his reading can be definitely enlarged by the addition not of more and more novels, nor merely of a few popularizations, but of an entire department of literature. In this literate age, it seems improbable that he will not be eager to read the great books of scientific literature—once he knows that such a body of material exists.

Both writer and reader, then, need an introduction in the form of a history of scientific literature, planned and carried through much as more general histories of literature are. I have been unable to find any such history as yet in existence. Mrs. May Lamberton Becker, gifted

editor of "The Reader's Guide," had never heard of any such book, nor had the late Professor E. E. Slosson, founder of Science Service, which supplies syndicated scientific news articles to many American newspapers. In the preparation of this volume a special questionnaire was sent to about fifty leading men of science and literary critics. One of the questions read as follows: "Do you know of any book devoted to a criticism, evaluation, or history of scientific literature regarded primarily as literature? Please give names." A few persons did not answer at all. One answer, evidently based on a misunderstanding, named De Kruif and Harrow. All the others were unanimous in answering "No."

There are indeed certain treatments of parts of the field or of special phases. The late Dr. Martha Ornstein in 1913 published an interesting dissertation on "The Rôle of the Scientific Societies in the Seventeenth Century," which, however, touched but lightly upon the literary aspects of that marvellous intellectual reformation. Further, by limiting her treatment to that early period, she excluded all consideration of the equally great, nearer, and—to us—more interesting nineteenth century. In the same year Dr. Carson S. Duncan issued his stimulating book, "The New Science and English Literature in the Classical Period." Dr. Duncan's work is made up largely of a chronicle of purely literary satires and burlesques upon the so-called "virtuoso" or eccentric scientific amateur who, with his clumsy instruments and haphazard collections of curios, apparently cut rather a laughable figure in the age of pure reason. Neither of these books would help much in guiding a reader toward fruitful reading and discrimination in scientific literature. Each has its own purpose to serve, neither of which was the one that is called for here. A nearer approach to the present problem is found in "The Development of the Natural History Essay in American Literature" by Philip

Marshall Hicks (1924). This book presents a critical and historical account of one phase of scientific literature. Dr. Hicks, by choosing to treat only the natural-history essay, avoids the risk of seeming to encroach upon alien provinces. The natural-history essay, as written by Thoreau, Emerson, and Burroughs, has long been recognized as belonging to literature, so much so that some would exclude it altogether from science. A more far-reaching, more recklessly ambitious—more foolhardy—program may not be out of order. It is the aim of this book to treat of unquestionably scientific writings, some of which have never been thought of as literature, in quite the same way.[5]

To some extent, this has been done in single chapters of literary histories. Professor A. H. Thorndike's "Literature in a Changing Age" (1924) devotes a suggestive chapter to the implications of scientific progress and the literature in which it is expressed. So, too, Hugh Walker gives over one chapter of his "The Literature of the Victorian Era" (1909) to a discussion of some leading scientific books. The "Cambridge History of English Literature" does likewise. It is from such treatments as these that the present volume derives; its aim differs from theirs only in that it means to concentrate upon scientific literature so as to cover that part of the literary field in somewhat more detail.

Yet to do justice to scientific literature in a single book is impossible. Whole libraries cannot contain the scientific output of even a single nation, while the imagination staggers before the vast bulk of what has been produced in the various languages of Western Europe and America. The catalogue of scientific papers read before the Royal Society of London during the years 1800 to 1900 fills seventeen volumes. Remember: that considerable space

[5] See also the American Library's Association series of pamphlets, "Reading with a Purpose."

is needed *merely to list the titles* of papers read before a single society. "The International Catalogue of Scientific Literature" requires *one hundred and ninety-seven volumes for the titles* of books and papers published during less than twenty years in sixteen sciences.[6]

Therefore this book has been reduced to a consideration of the literature of nineteenth-century science, with just a little overlapping here and there for purposes of introduction or transition.

The nineteenth century has several distinct advantages as a field for study of this sort. Of all periods that have come to an end it is the nearest to our own. Despite inevitable changes in taste, morals, standards so great that "Victorian" and its synonym "respectable" have become terms of abuse, we have spiritually much in common with that age. Of all Victorians the scientists are possibly the nearest to ourselves. In general they were inclined toward liberalism and realism. Much of the detachment, objectivity, freedom from dogma boasted by the post-war generation belonged to the naturalists of the sixties and seventies. A great part of the current philosophy of life is but a natural outgrowth of Victorian discovery. Further, the nearness of that age supplies us with material in greater fulness than does any earlier period, not only in the form of many, many books, but in the living reminiscences of persons surviving since that time.

But above all, the nineteenth century was the great flowering age of science. Not only were more discoveries made, more links found to bind together coherently what had been known before, more useful applications of science devised, but somehow the population of the world became more definitely aware of science and its potency. Before that time it had been a stepchild of philosophy; today philosophy is on the defensive while science is

[6] The earliest date is 1901, the latest 1919; however, no list covers all those years, and the lists for some of the sciences cover only a single year.

yielded preëminence. The nineteenth century intervened and has caused the change.

Rash though it be to comment on the too-near present, one may well consider our own age less preëminently the age of science than the last. Though we have more machines than our grandfathers, though we have gathered more facts, overturned more theories, and replaced them with more new theories than they, we lack the robust optimism that marked their attitude. The Victorians had a faith in science, as in progress and in democracy, as yet unshaken by gas-bombs, psychoanalysis, talking-pictures, and bloated industrial cities. The man of science foresaw nothing but greater wisdom and greater dignity accruing to man as the result of his researches and accordingly proceeded lustily upon the crusade of discovery. There was little, if anything, of the futilitarian atmosphere that sickens so much of twentieth-century culture and makes the discovery of man's smallness in the universe and his destined extinction no glorious emprise. Science was young in spirit, hopeful, on the increase.[7]

As compared with the scientific literature of earlier periods, that of the nineteenth century was marked by a decided increase in what we are obliged to call "scientific quality." Before that day, a great part of the scientific writing was cast in molds or given a stylistic handling in no way distinctive. The Augustan age had its lectures in verse much as the seventeenth century had its philosophical dialogues. It would be harder to isolate a body of scientific literature from other writing before 1800 than since. Scientific thought seemed to attain its maturity then and to win some independence from theology and philosophy. Even during part of the nineteenth century, the presumed "purpose" of some natural phenomenon was

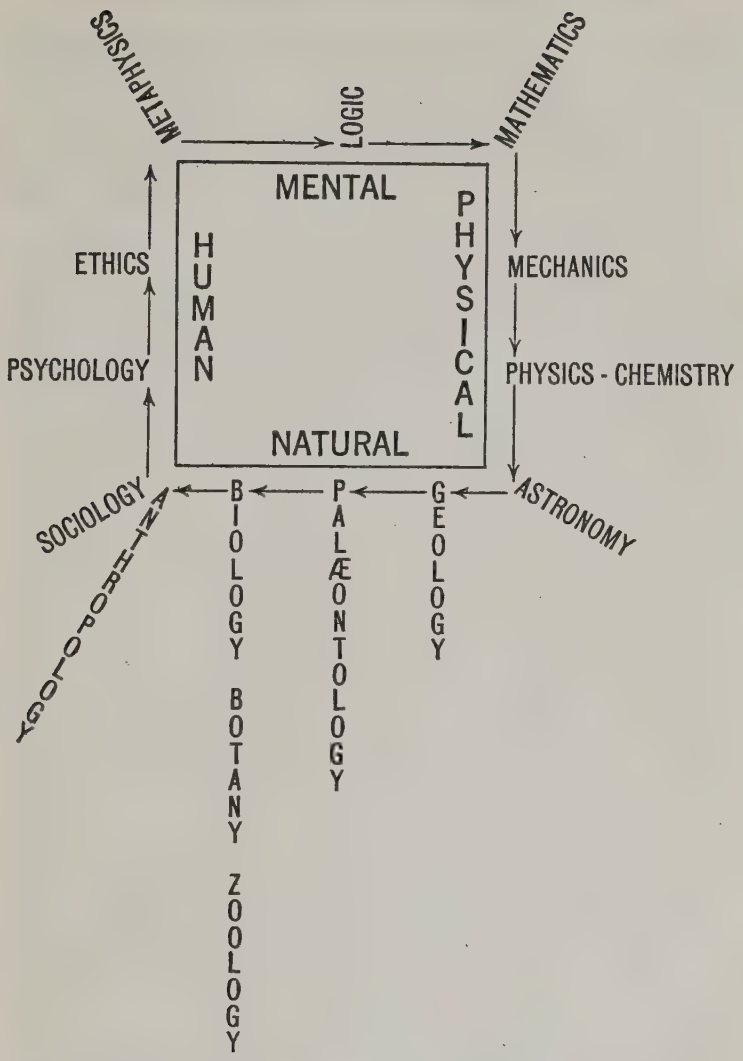
[7] For a typically optimistic view of Victorian science, see A. R. Wallace, "The Wonderful Century," 1899.

given in treatises as a reason for supposing its structures to be of a certain kind. Much reasoning was of this *a priori* sort, and only repeated and bitter conflicts rid science of it. Scientific literature, then, for the first time became itself. On the other hand, it had not yet reached the extreme of specialization which makes so much of recent writing inaccessible to any large number of readers and therefore diminishes its chance of receiving a human, artistic interpretation. During the Victorian period some of the most original and important books were so written that they both command the respect of the expert and win the enthusiasm of the unspecialized reader.

These reasons have served to suggest that these chapters be limited in general to a consideration of nineteenth-century work. In the same general way, it has seemed best to treat scientific literature as a phase of Victorian civilization. This suggests that the study be limited to work done in England, continental and American products being treated only incidentally and usually in their relation to English scientific literature.

A more important limitation is that of the subject-matter. Not all sciences are alike either in the mental qualities which they demand of their devotees or in the kind of expression that may be expected. Some, like advanced pure mathematics, make so large a use of conventional symbolism that new standards of literary criticism must be devised if books on such a topic are to be classified and interpreted as literature. "Science employs symbols for expressing its facts and relations, and cannot accomplish this by words and sentences." [8] Further, these same abstract sciences, dealing as they do with matters of ideal number, space, direction, proportion, position, provide least food for imagination, the emotions, and the forms of language that play so large a part in humanized presentation. It would be idle to argue that

[8] A. H. Thorndike, "Literature in a Changing Age," p. 230.



A new classification of the sciences. They are here divided into four groups, each of which is further subdivided into other groups. They are shown in a cycle of arrangement which indicates the mutual interdependence of the sciences upon one another.

they cannot be made the substance of literature; but, since, for purposes of the present study, the field must perforce be limited, it seems more natural for a first discussion of scientific literature to take up that part of science which can more obviously be made the material of literature—the group of loosely related studies that make up the natural sciences.

In a later chapter much will be said concerning attempts at a classification of the sciences. Auguste Comte pictured them as following a *serial* arrangement, each one above another upon which it depended for its fundamental concepts. Herbert Spencer pictured them as the branches spreading from one stem, all basically divisible into the abstract and the concrete. For purpose of literary study, there is another possible arrangement, the *cyclical*. The attached diagram shows all the major sciences arranged under four headings—the mental, the physical, the natural, and the human sciences—which at the ends blend into one another. One cannot place any one science at the foundation because each can be seen to derive from the one just before it and to sustain the next one following in an endless cycle. Some of the branches meet at the extremities and coöperate with others than their nearest neighbors. Some can be seen to belong more or less in two groups, as astronomy in both the physical and the natural divisions and anthropology in both the natural and human divisions. Of all four divisions, the natural sciences, which, including the two at the ends, form the largest group, have most literary possibility. The present discussion will have more to say about that division than about the others.

Concerned chiefly with the literature of the natural-history group of sciences as produced during the nineteenth century, this study inevitably centers about the work of Charles Darwin. His discoveries in general biology, in botany, in zoölogy, in geology, in the past

history of life on earth were among the most important of all time. The great generalization of evolution through natural selection, whose greatest advance was due to his efforts, is one of the few products of past thought that continue to be fruitful, that continue to hold interest and to motivate further thinking. There is scarcely a branch of scholarship today without its own evolutionary hypothesis, for the Darwinian mode of attacking unsolved problems is now universally in evidence. The substance of his doctrine has become likewise far-reaching in its influence. The very disillusion of the years following the Great War has been couched by quite unscientific poets and novelists in terms borrowed from the idea of a struggle for existence, a "materialized logical process," a natural selection of the individuals fittest to survive. The resulting belief in the animal descent of man has colored the views and the philosophy of our generation far more than Darwin himself could have foreseen.

He was, furthermore, an almost perfect incarnation of the ideal scientist. His patient, cautious, resourceful mind, ever on the alert to catch itself in error, ever insistent upon reliable verification of its own conclusions, has been regarded as the model upon which every scientific mind should be molded. The quiet but unmistakable persistence with which he would follow an idea as far as scientific method would allow, the dispassionate clarity with which he pursued observable truth, undeterred either by his own preconceptions or by the powerful convictions of all society, his courage in espousing new principles, his modesty in yielding up discredited old ideas—all these go to illustrate the typical character of the scientist.

That would suffice to make him the most important single figure in such a book as this. But Darwin was something more than a very great scientist; he was a writer of considerable skill and unusual inspiration as

well. Not consciously a popular man of letters, like Huxley, not a mere popularizer of science, not one who ever sacrificed truth of substance to charm or impressiveness of form, he nevertheless wrote with clarity, beauty, and rare human appeal. The late John Kendrick Bangs tells of a Western miner who learned to read after reaching maturity, using "The Origin of Species" as his primer. That strange tale is not incredible, such is the simplicity of Darwin's style and such the candor and naïveté of his personality, never absent from his writings.

More than any other man of whom I know, Darwin united within himself and typified in his writings the various qualities that go to the making of real literature which is also genuine science. It is no less appropriate to devote much of such a book as this to his life and work than it would be to devote a large part of a volume on Elizabethan dramatists to a study of Shakespeare. This is not intended as a study of Darwin, but he happens to be the best exemplar of what this book does mean to explore.

It is obvious that little originality can be expected. The materials for Darwin's life are conveniently collected in various books by his son, Francis Darwin, and other biographies present more or less rounded accounts of his life and work. Most include some discussion of his ability as a writer. This present treatment differs from others chiefly in two respects: it greatly increases the emphasis upon his writing as such, including considerable literary analysis, and it seeks to orient his writings by a study of his predecessors and contemporaries in the same field. Other works—for example, Professor Henry Fairfield Osborn's "From the Greeks to Darwin" (1894) and Dr. John W. Judd's "The Coming of Evolution" (1910)—have discussed some of these contacts, but neither they nor any other have studied the literary implications to any great extent. It is in regard to such literary study that this volume seeks to break ground.

To avoid the one-sidedness of a mere study of evolutionary literature, the fourth part has been included. It is divided into four sections, each of which briefly resumes the literature of a special phase of writing about science. In that part, unlike the second and third, the books mentioned are grouped not according to subject-matter but according to the author's attitude, which largely determines the literary form of any book. In that part, the self-imposed limitations of subject-matter are therefore overstepped at times. Physics, chemistry, and even mathematics come in for a share of comment; that is, popular presentations of these sciences are discussed under the head of popularization.

Throughout the volume, most points made are illustrated liberally by means of long, short, or fragmentary selections, for scientific literature is still so generally unfamiliar to readers that one dare not presume upon its being known. In part, this is a volume of original sources, illustratively used. Books of scientific selections, generally intended as texts for the teaching of rhetoric, are not entirely unknown. Maurice Garland Fulton's "Expository Writing" includes numerous extracts of the sort; Charles H. Ward's "Exploring Nature" (1923) and William S. Knickerbocker's "Classics of Science" (1927) both present selections to be studied in the English class. The present volume does not aim to be a class text, either for rhetorical practice or for practice in the analysis of individual literary essays, and therefore does not encroach upon the province of those books.

There are numerous possible aims besides those which have been chosen for this book. Perhaps it would be well to list briefly some of the things which it does not pretend to be. In the first place, it is certainly not a work of science. It does not aim to make any original contribution to the substance of any science, nor to criticize authoritatively any scientific doctrine. It does, when

necessary to carry on the current of literary exposition, present brief summaries of what great scientists have written. Sometimes it has been necessary to criticize the purely scientific opinions of the men being discussed; in such cases I have followed the practice of finding some competent authority for each criticism levelled. Perhaps this book ought to have been written by a trained practicing biologist or physicist, but, as none has thought of doing so, anyone who has had the idea has the right to carry it out. And even if a biologist or a physicist had undertaken this work, he would have been obliged to attack it as a student of literature. Perhaps a student of literature may be justified in approaching this field as a literary province though admittedly without scientific authority of his own.

Furthermore this is not a work of popular science. Its aim is not to render the substance of difficult scientific books intelligible to the uneducated, but to discover the literary quality inherent in scientific classics, many of which were not intended for popular reading at all. Nor is it a criticism mainly of popular scientific writing to the exclusion of other kinds; a brief glance at the titles of the books treated will sufficiently indicate this.

This is not intended as an original history of science, prepared in competition with, or in opposition to, any of the excellent histories of the various sciences which have long been available. Just enough scientific history is included to make it unnecessary for the reader to refer constantly to some other book while tracing the *history of scientific literature* that is given in this one. And it is not primarily a work of biography, stressing the lives and personal stories of scientists, as "Microbe Hunters" is, for example. Only one biography is given in considerable detail. Others are taken in for the light which they shed upon the literary production of the men studied.

There is one other point liable to misunderstanding; this is not a book about religion, nor an attack on any form of religion. In narrating the history of scientific literature during the nineteenth century, one must tell of the conflicts that occurred during that period, most of which skirmishes ended in defeat for those who upheld the conservative view of religious dogma. Often enough this has been due solely to the unfortunate tendency of certain religious spokesmen to attach their faith irrelevantly to some old scientific doctrine, and, when that doctrine was threatened, to spring forth, with equal irrelevance, to its defence. John Fiske has well said that[*] "the hostility between Science and Religion . . . is purely a chimera of the imagination. . . . The real conflict . . . is not between Knowledge and Aspiration, but between the less imperfect knowledge of any given age and the more imperfect knowledge of the age which has gone before."

Men of science, like other human beings, differ widely in their attitude toward religion. The December 1928 meeting of the American Association for the Advancement of Science was ruffled by a dispute between President Henry Fairfield Osborn and Professor Harry Elmer Barnes on this very question. One of these eminent savants proclaimed his own lack of faith; the other, equally distinguished for scientific attainment, publicly condemned that pronouncement. Professor Robert Andrews Millikan, Nobel Prize winner for original discoveries in physical science, delivered a course of three lectures at Yale during 1926, in which he declared that the newer discoveries of the physicists, by superseding the crude materialism of the nineteenth century, have diminished the old-style "cock-sure" attitude of scientists that what they know is identical with the whole truth.

[*] "Outlines of Cosmic Philosophy," Preface.

He is the author of a book entitled "Science and Life" (1923) which has been described as "a plea for the supremacy of the spiritual."

In the biological field there have been similar attempts at a rapprochement between religion and science. Perhaps the most spectacular of such events within recent months has been the publication of a book entitled "Creation by Evolution, A Consensus by Leading Authorities, edited by Francis Mason" (1928). Here (as the "New York *Times*" reviewer put it) "twenty-six scientific lions lie down with the lamb." Obviously, dealing as it does with matters of which it is impossible to have certain knowledge, no such book can be scientifically authoritative. Its importance lies in this thought: if so many scientists of unquestionable distinction have been able to see reason for faith, science need not be viewed as the inevitable foe of religion.

One of the sensations of recent popular—and incidentally of professional—scientific writing has been "The Nature of the Physical World" by Arthur Stanley Eddington, Plumian Professor of Astronomy in the University of Cambridge. Professor Eddington has been described as [10] "not only a scientist and expounder of science but a Christian mystic who interprets the philosophic significance and defends the religious implications of his austere formulas." What are those implications? In the first place, " 'dead matter' is dead, and something that is much too lively for comfort, at least for intellectual comfort, has taken its place." The theory of relativity has turned material into force and abstraction, "and the more shadowy the material universe becomes the more need for inferring a reality beyond it." "It will be strange if Eddington turns out to be right, and if the new physics with its concepts of Entropy, Relativity, and Quanta is

[10] Quoted from "Beyond Physics" by W. P. Montague, in *Saturday Review of Literature*, March 23, 1929. See A. S. Eddington, "Science and the Unseen World," 1929.

destined not only to increase our mastery of earth but also to restore the old and dangerous hope for something beyond."

This lengthy digression is intended merely to indicate that the oft-presumed conflict between religion and science is not, in the opinion of some who should know, inevitable and essential. Even if it were, the present book ought not to be considered in any sense a brief on either side of the dispute. Its historical portions must narrate what happened; that is all. If Huxley, gifted scientific debater, disputed with and overcame the Bishop of Oxford, the honest chronicler must record that event. Since this is a study of Huxley's career (among others), the presentation must be sympathetic. As the bishop happened incidentally to have taken the wrong side in a purely scientific controversy, the fact that he was mistaken is not really a religious occurrence at all, and the fact that this book records his discomfiture is not an attack upon religion.

Nor can the present study find room for an account of those vast and growing fields of imaginative literature which have been more or less influenced by the scientific advance. The scientific romance, as exemplified in the novels of Jules Verne, the short stories of Fitz-James O'Brien, and the early works of H. G. Wells, offers ample matter for a treatise of its own. Perhaps some day that treatise will be written, but one must not expect to find it here.

There are many other points at which science impinges upon what is universally recognized as literature, full of possibilities but at present out of our scope. There is, for instance, the "laboratory novel" or "naturalistic novel," in which the lives of human characters are delineated with the cold, objective impersonality of the laboratory investigator—as Émile Zola and others have conceived him to be. Like the scientific romance, the labora-

tory novel belongs in the field of fiction and therefore does not concern us now.

A great part of the more significant literature of the day, in all its forms, shows unmistakable marks of the influence of science. This has been given some discussion of late. For example, I. A. Richards' little volume on "Poetry and Science" (1926) expounds a psychological process whereby one's understanding of the universe, at first a wholly scientific and analytical possession, becomes part of the psyche and hence the material of poetic expression. Oliver Ellis's "Poetry and Science and Other Essays in Prose" (1924) seeks to show that both are essentially one—an imaginative search for truth; "it is the seeking, the knocking that is Science; it is the finding, the partial success, that is Poetry." Likewise, Dr. Henry W. Wells devotes a portion of his suggestive book, "The Realm of Literature" (1927) to an analysis of the relation of science and art, notably literary art. He foresees an alliance between the two with prospects "so vast that at the present juncture it would be far too bold to prophesy what types of art scientific themes will produce." "Is it, then," he inquires, "an altogether fanciful conjecture that the Greeks were endowed with a prophetic wisdom when they held the worship of all art and science to be the service of the one god, Apollo?"

Long ago—in his immortal preface to "Lyrical Ballads"—Wordsworth declared: "The remotest discoveries of the chemist, the botanist, or the mineralogist will be as proper objects of the poet's art as any upon which he is now employed, if the time should ever come when these things shall be familiar to us, and the relations under which they are contemplated shall be manifestly and palpably material to us as enjoying and suffering beings."

Using that quotation as a text, Mr. Aldous Huxley has constructed an essay on "The Subject-Matter of Poetry" (1922). He admits the theoretical value of scientific

material for a new "metaphysical" school of poetry, which unfortunately has not yet produced "a single poet of real importance, not one great or outstanding personality. The twentieth century," he concludes, "still awaits its Lucretius, awaits its own philosophical Dante, its new Goethe, its Donne, even its up-to-date Laforgue. Will they appear?"

Nevertheless, it is unquestionable that minor poets whose vision of life has felt the impact of science have appeared, and one need only run down the list of recent dramatic productions—from "R.U.R." and "The World We Live In" to "Wings Over Europe" and "Dynamo"—to realize how far that branch of literature has seized upon scientific discovery in a way that is "manifestly and palpably material to us as enjoying and suffering beings." [11]

There are two obvious ways in which science naturally tends to influence literature: applied science, by changing the world in which we live, changes life itself, and presently literature feels the effect; and pure science, by changing the form and quality of thought, works upon literature, which is, after all, largely an expression of thought. Recent examples of the former are found in many volumes of the *"Today and Tomorrow Series."* For instance, "Dædalus, or Science and the Future" by John Beresford Haldane (1924) contains a number of predictions as to coming inventions, which, if realized,

[11] An interesting variant of the same theme is found in the collection of statistics concerning great poets to whom some branch of science was either a profession or a hobby. During the late convention of the American Association for the Advancement of Science, in December 1928, Dr. Gerald B. Webb spoke upon "The Rôle of Physicians as Poets and Men of Letters," citing a formidable array of writers, from Oliver Goldsmith and earlier men to Dr. Robert Bridges, the recent laureate, who have been physicians. In a similar address before the Royal Institution (on June 4, 1920) Colonel Sir Ronald Ross, famous discoverer of the malaria-bearing mosquito, listed Coleridge, Browning, Tennyson, Campbell, Shelley, Keats, and Goethe among those poets who have been drawn to scientific pursuits. But this is rather a curiosity of literature than an instructive investigation.

will change the conditions of life fundamentally, so fundamentally that tremendous changes in literature must follow. He describes science as "man's gradual conquest, first of space and time, then of matter, as such, then of his own body and those of other beings, and finally the subjugation of the dark and evil elements in his own soul." As a result of this progress, "no beliefs, no values, no institutions are safe." Though it is impossible to foresee the effects upon literature of such shifts in focus, obviously there must be changes of vast scope.

The effect of science upon current thought is at least equally great, and many books have been written to explain it. "Essays by a Biologist" by Professor Julian Huxley (1924) constitute "an attempt to apply his own biological conceptions to the whole gamut of human knowledge and effort." Professor C. Lloyd Morgan's "Emergent Evolution" (1922), like Bergson's doctrine of creative evolution, seeks to do metaphysical work strictly based upon facts and limited by methods of physical and natural science. How this is reacting in the cultural life of our time has been keenly outlined by Professor Frederick Barry in "The Scientific Habit of Thought" (1928). Says he: "The educated man whose interests are restricted to the older humanistic range feels, oddly, not out of place but somewhat detached. . . . He is made to feel that he is living on the surface of things; out of touch with great events, the stir of which he feels but cannot grasp. . . . There is an unmistakable tone of earnestness in nearly all discussion. . . . The scientific discoveries of the nineteenth century have actually remodelled the structure of western civilization. . . . The foundation of all cultural education must henceforth be significant knowledge." Dr. Henry Seidel Canby editorializes thus in *The Saturday Review of Literature:*[13] "The serious criticism of the twentieth century is dominated

[13] November 12, 1927.

by experimental science . . . where criticism is alive and vigorous in our day, it is as inevitably attracted toward scientific thinking as the copper brush toward the electro-magnet."

These matters rather promise a future scientific influence upon literature, by way of life and of thought, than record any such influence as already bearing fruit. Professor A. H. Thorndike declares [18] that "there is no imaginative sythesis, no attempt to create a lasting memorial of what this scientific progress has meant for mankind. Modern science has not found a great poet. . . . Literature still stands somewhat hesitant on the threshold of this towering palace of imaginative wonder."

Tempting as it is to explore all these varied fields, the mere shortness of life makes that feat impracticable. One who wishes to make the contact between science and literature is therefore compelled to choose among them. No choice of a province in which to work seems to me more appropriate for a first exploration than what has been made here. This book has selected the unquestioned masterpieces of a group of related sciences—that group whose subject-matter is essentially most interesting to most human beings. It has chosen one of the most vital periods in the unfolding of those sciences to narrate the history of their literature with chief emphasis upon its literary aspects. And a glimpse is given into what Professor Thorndike calls "the need of informing delightfully" under which "the expository art has acquired a host of new devices and charms."

The expository art, then, as practiced by leading biologists, geologists, naturalists, popularizers, and some other scientific writers in England during the nineteenth century, is here recorded. Almost all of us require to be made more aware of these aspects of scientific writing. Even engineers, practical men of calculating, constructive

[18] "Literature in a Changing Age."

minds and active work rather than of words, are in need of this new viewpoint,[14] as has been amply shown by the remarks of President Morgan of Antioch College and the studies of Mr. William E. Wickenden, Director of Investigation for the Society for the Promotion of Engineering Education. Critics, men of letters, and literary scholars will necessarily work under an avoidable handicap unless they are familiar with the main lines of scientific thought, the principal technical maneuvers of scientific exposition, the essential philosophical implications and literary consequences of the scientific advance. That hypothetical being, the average reader, can raise the level as well as extend the boundaries of his average reading greatly, if he but realizes that there is a wide land of scientific literature for him to explore, some of which, at least, has not been emasculated. Finally, the writer of books on scientific subjects can vastly increase the number of his readers and the efficiency of his presentation by means of "increased attention to the literary art."

[14] See "What Does an Engineer Do?" *Scientific American*, Dec., 1926, and "An Engineer's Valuation of English," *English Journal*, June, 1927.

PART I

THE FIRST THIRTY YEARS

THE CATASTROPHIC WAR

I perceive, said the Marchioness, philosophy is now become very mechanical.

Fontenelle.

There is precisely the same proof that an eye was made for vision as there is that the telescope was made for assisting it.

William Paley.

Time, which means everything in our idea, and is often deficient to our schemes, is to nature endless and as nothing.

James Hutton.

The result, therefore, of this physical inquiry is, that we find no vestige of a beginning,—no prospect of an end.

We are not to make nature act in violation to that order which we actually observe.

James Hutton.

True philosophy is to see things just as they are.

Buffon.

I must write what will be read.

Sir Charles Lyell.

Does the newly proposed view remove more difficulties, require fewer assumptions, and present more consistency with observed facts than that which it seeks to supersede? If so, the philosopher will adopt it, and the world will follow the philosopher—after many days.

Grove.

CHAPTER II

BOUNDLESS PROVIDENCE OR LIMITLESS CHANGE

(Paley and Hutton)

During the tottering years when the eighteenth century was yielding place to the nineteenth, two books were written that were destined to play mighty and opposing rôles in English thought for generations. One of these, the "Natural Theology" of William Paley,* was at its inception, and continued to be, eminently respectable, for it was a bulwark of faith, which it buttressed with elaborately coördinated logic. The other, written by a Scotch doctor named James Hutton and called "The Theory of the Earth," became all unwittingly the centre of one controversy and the starting-point of two more. Hutton had dared to conclude that "time is long," that the birthday of the earth was very much more ancient than the ecclesiastically authorized October 4, 4004 B.C. Before Hutton there had been scarcely a science of geology; when his work appeared, the newly named study burst into existence with volcanic fury.

Two books in allied fields, yet more unlike it would be difficult to imagine. Paley began with the premise that the universe is a cosmos, a world of order and design so perfectly balanced as to convince any rational mind that it must be the work of an intelligent creator. Unfortunately there were "infidels" in Europe, men who used their minds to other purposes than the greater glory of God. As the devil must be fought with fire, rationalist unbelievers had to be convinced with logic. Step by step

* (1743-1802.)

the analytical process led Paley into the unusual situation of defending blind faith by means of skeptical arguments that granted little, if anything, on faith alone. It is natural that the scholars of the Established Church—who often enough are skeptics in all but official acknowledgment—accepted that book as a standard expression of their own view of the universe. Years later Darwin, a singularly candid man, accustomed to scientific thinking, wrote to Sir John Lubbock, "I do not think I hardly ever admired a book more than Paley's 'Natural Theology.' I could almost formerly have said it by heart." More unexpected still is the analysis of it given by Thomas Henry Huxley, who, it must be remembered, was constantly warring against unscientific traditions. He declared that Paley admitted "proleptically" the truth of Evolution by seeing in the process of creation "trains of mechanical dispositions fixed beforehand by intelligent appointment."

Though Paley's book appeared in 1802, in all things it continued an attitude common among eighteenth-century thinkers. It saved the body of faith by working through the spirit of rationalism. Yet, rational though it was, it stopped before the great First Cause and thus did not pursue reason with entire consistency. It was a compromise, a characteristically British work.

Now Hutton * worked quite differently. He was no philosopher. He knew naught of hair-splitting subtleties and he had no fixed idea, no single dogma to maintain. His work had showed him how constantly earth and rock are worn away by raindrops and by flowing streams. Instead of being content with general aphorisms, such as that "constant dropping wears out even stone," he undertook the simple scientific problem of determining how much dropping would be required to wear out a given quantity of stone. He took some measurements and calculated from them that, if river valleys really have been scooped out by their rivers, assuming the rate of work

* James Hutton (1726-1797).

to have remained constant, a much longer past must be granted them than the customary chronology would allow.

Soon some one noticed that this meant a disagreement with Scripture, which lays down six days as the time in which the world was created and less than 6000 years for subsequent history. A controversy began, but it was not a mortal combat, for reconciliation was possible. As early as 1806 Dr. Thomas Chalmers, who later acted so heroic a part in the Great Disruption of the Scottish Free Kirk, spoke on this subject, pointing out that "the writings of Moses do not fix the antiquity of the globe." Eight years later, in his "Review of Cuvier's Theory of the Earth," Dr. Chalmers produced what Hugh Miller called "a more elaborate scheme—perfectly adequate to bring the Mosaic narrative into harmony with what was known at the time of geologic history." His elaborate scheme is certainly remarkable. He does not conclude, as some have done, that the six days of Creation were in reality six ages of gradual development, but supposes instead that they actually were six natural days of twenty-four hours each; however, before this whole work of creation began, there may have been uncounted eons of gradual, chaotic development. Writing in 1856, Miller tells us that this scheme of reconciliation had been widely adopted.

Hutton's idea, however, had not yet come safe to port. His theory of denudation, or the wearing away of land surfaces through the action of water, did not explain how the land came to be there in the first place. He had some new ideas on this subject. He held, for instance, that all existing lands are made up of the remains of earlier, outworn continents. Their *detritus,* gradually accumulating upon the bottom of the sea, formed vast beds or strata of secondary rock. Heat, acting upon such masses under tremendous pressure, *consolidated* them, after which forces such as those of volcanoes and earthquakes acting from within the globe had raised the solid crust above

sea-level and folded it into mountain-ranges. This part of his hypothesis was contested by Werner, a German scientist, who thought he could prove that all rocks were formed by the slow settling of layers of sand within shallow oceans and shaped by the erosive effect of running water into mountains and valleys. As so often happens, there was truth on both sides, but the geological world did not see it and was cleft into two hostile camps. Those who believed in volcanic action were derided under the title of Plutonists. These fiery ones sneeringly dubbed their opponents Neptunists.

The greatest of the Plutonists was Professor John Playfair,* who taught mathematics in the rising University of Edinburgh. He had been a friend and disciple of Hutton, and he burned with indignation at seeing his late master's achievements misunderstood, his theories denied by people who did not grasp their meaning. Convinced that this sad state of things was due to the dry and perplexing style employed by the Father of Geology (though, curious as it must seem, his conversation had "no less clearness and precision than animation and force") Playfair set to work to give suitable presentation to Hutton's ideas. This he did by means of his "Illustrations of the Huttonian Theory of the Earth," published in 1802, long an authority and still a valuable curiosity of literature. Playfair writes clearly and sensibly, though not gracefully, sometimes with force or even with grandeur. To a twentieth-century eye, much of his work has a flavor of quaintness. In the copy that came to me an anonymous critic had pencilled this comment: "Our scientific writers have much to learn from Playfair with regard to the smooth, readable, and interesting style of this book."

His purpose was controversial: in a short essay (125 pages) followed by a long series of notes, he "illustrated" and defended the Huttonian theory, especially the Plu-

* (1748-1819.)

tonian part of it. He presents an excellent case; De Luc and Werner, the leading Neptunists, look quite absurd in the dry light of fact and logic that he sheds across and through their reasonings. He was most bitter against one Richard Kirwan, who had attacked the Huttonian theory because "the high antiquity ascribed by it to the earth is inconsistent with that system of chronology which rests on the authority of the Sacred Writings." Kirwan himself was more of a chemist than a geologist and, in disputed matters, an excellent compromiser. He explains the Mosaic statement that light existed before the sun was made by saying that terrestrial volcanoes gave forth light. To his and like objections, Playfair replied that on the great question of the age of Man, "geology is silent" while Scripture is not much concerned with the mere age of rocks. Furthermore, Science had always given to Hutton's mind a sense of "plan in nature," showing "that it produces seas and continents, not by accident, but by the operation of regular and uniform causes."

The great Goethe took a keen interest in the battle, which he portrayed satirically in the *"Walpurgisnacht"* interlude of *"Faust."* ... Years afterward, largely through the work of Sir Charles Lyell, the differences were compounded; it was recognized that some rocks are *igneous* or produced by fire, while others come to be through the action of water and are called *aqueous.*

Meanwhile a subdivision of geology was developing, in the study of fossils. These puzzling objects, that seemed to belong at once to the animal kingdom and the mineral, had been known long but were little understood. Nicolas Steno in 1669 had discussed them in his book, *"De Solido intra Solidum,"* and later scholars had regarded them with attentive eyes. They had been mentioned by Leonardo da Vinci. Yet in 1800 a common explanation was that just as every species of living thing had been separately

and specially created and had remained unchanged ever since, so, too, fossils had been created, in the beginning, of stone yet in the forms of animals and plants. If any asked why creation should have brought forth so strange a product, he was told that it had done so "to mock the pride of man" by showing one thing at least that his intellect could not grasp.

The studies of John Hunter and of the Italian Spallanzani in the late eighteenth century had shown many analogies between the bodily structures of very various creatures, both contemporary and extinct, so as to indicate, if not to prove, a physical kinship between them. Jean Baptiste Lamarck, a great though sadly neglected zoölogist, more daringly asserted this kinship; from the year 1800 on he worked his way toward an ever more complete theory of the evolution of species from other species. But it was William Smith, a surveyor known variously as "the father of English geology" and as "Strata Smith," who first combined the science of life with the theory of the earth and brought forth the new sub-science of palæontology. In 1814 he published his "English Strata Identified by Organized Remains," whose main thought is clearly told by the title.[1] He had noticed that certain kinds of rock contain certain kinds of fossils only—fossils never found in other rock formations, which, in turn, have special fossil-populations of their own. He concluded that there had been several great and sharply distinguished epochs in the earth's existence, during each of which this planet was inhabited by characteristic and special forms of life. So far, so good. But to account for the complete disappearance of each successive wave of life before the emergence of the next, Smith's disciples had to do what was beyond their power, the facts ready

[1] Other works by Smith: "Order of the Strata and their Imbedded Organic Remains in the Neighborhood of Bath examined and proved prior to 1799"; "A Geological Map of England and Wales, with part of Scotland," 1815.

to hand being so very meagre. Baron Cuvier, for example,[2] assumed that each long geologic age had ended suddenly and fearfully with what was called a "catastrophe," some terrible and widespread cataclysm that had once and for all wiped out the entire life of the age whose final curtain it was. In one case the catastrophe might be a flood, in another an earthquake, or a volcanic eruption, or a subsidence of the land, or a rising of the ocean bed, or something more mysterious and dreadful still. After each catastrophe, the bodies of the slain would be entombed in the stratum of typical rock that formed over them, and in the fulness of time, Providence would again repopulate the earth with new life, more complex, more varied, higher than what had been destroyed.

The thought that at least one of these catastrophes may have been a universal deluge appealed to the scholars of an age that was trained in theology. The same minds that accepted Dr. Chalmers' harmonizing of Scripture and science saw in this doctrine a further detail of reconciliation. As late as 1824, after other discoveries and the publication of more books had complicated the matter further, the Rev. Dr. William Buckland issued his "*Reliquæ Diluvianæ,* or Observations on the Organic Remains Found in Caves, Fissures, and Diluvial Gravel, Attesting The Action of a Universal Deluge." This title, unlike modern newspaper headlines in its quaintness and length, is yet like them in this: it tells the whole story right at the start. The one strange circumstance is that the system of thought which that book presented was for a time the regular and orthodox one. Life had been created by the Divine Power in several separate spasms, each age being frightfully ended by a catastrophe. Seen in the large, the history of life had been progressive, yet all species now known had been created specially "each

[2] See Cuvier's "*Discours sur les revolutions de la Surface du Globe*" and Chapter VIII below.

after its own kind," for no man had seen figs come forth from thistles. Such was the doctrine known as catastrophism, and about it raged one of the fiercest and most significant struggles in the story of nineteenth-century thought.

CHAPTER III

THE EVENTS OF 1830

THE year 1830 is known as a time of revolution in Europe. It was then that the last Bourbon was hunted out of the Tuileries palace, and the oscillations caused by that shock were felt in the capitals of all continental states, in remote hamlets, and on the western shores of the Atlantic. On the August morning [1] when the most troublous tidings penetrated Weimar, a friend visited Goethe and found the aged poet strangely perturbed. Goethe had long been "physician of the iron age" of all Europe, "who laid his finger on the spot and said, 'Thou ailest here—and here' "; but his thoughts were not of politics that day. He had just heard of an epochal debate [2] that had taken place in Paris between Baron Cuvier, the scientific darling of government and high society, and Geoffroy Saint-Hilaire [3] on the subject of fixity of species. Cuvier was a brilliant, polished, and effective speaker; his knowledge was immense, and he knew how to make use of all of it. Besides that, he favored the side that was dear to human taste, religion, and current scientific orthodoxy—the side of special creation. Saint-Hilaire was learned and a blunt thinker, too original for the time. So far as his ideas could be recognized and classified at all, they were those of the eccentric and unpopular Lamarck. Catastrophism, then generally believed, was a real argument against his view, for how

[1] Soret and Haeckel, quoted by Osborn, "From the Greeks to Darwin," p. 183.
[2] See Chapter VIII below for details of the debate.
[3] Arabella Buckley Fisher (quoted in Sedgwick, "Short History of Science," p. 373).

could the animals now living be the modified descendants of extinct creatures, if those ancient monsters whose fossil remains we have found were all swept out of existence in the great flood of Noah or in other catastrophes? Surely there must have been successive creations, and, if successive ones, why not contemporaneous special creations, each after its own kind? Cuvier completely disproved the theory of evolution. Europe was convinced, and Goethe died two years after, not knowing that his favorite theory of "metamorphosis" was to triumph later, and that the first step in the progress toward that consummation had already been taken.

As a matter of fact, it was 1830, the very year of that historic debate, which saw catastrophism first successfully attacked. Sir Charles Lyell,* a singularly clear-headed and honest man and the foremost geologist of the generation then beginning, published in that year the first edition of his "Principles of Geology, Being an Inquiry on How Far the Former Changes of the Earth's Surface Are Referable to Causes Now in Operation."[1] This book, which ran through twelve English editions before 1875 and has seen several since, is one of the authentic classics of scientific literature, notable for force and beauty of style, consistency of design, and for the value of its matter. "In the days when it first appeared," says Mrs. Oliphant, "it was probably rendered more attractive by the delicately heretical flavour, which added a charm to all similar researches in those days but has now become too much a matter of course to interest anyone." Yet it is no great tax upon the imagination to catch some of the author's sense of daring, of treading high places to which no paths led and viewing magnificent prospects across valleys still virgin.

Lyell's starting-point was the boulder, or *roche mou-*

[1] In later editions its subtitle was "—or the Modern Changes of the Earth and its Inhabitants."

* (1797-1875.)

tonnée, that rounded rock, often tons in weight, which can be seen lying loosely in many a field. It is not connected with near-by strata in any way; it may be composed of entirely different minerals from those of any neighboring beds. Its shape shows that it has been rolled and rubbed and ground down. It is marked with long scratches that more or less correspond to similar grooves on the upper surfaces of rocks that crop out of the soil. How did it get to be where it is? All signs point to its having come from somewhere else. Some geologists answered that boulders had been swept from their original places by the waters of the great flood. Lyell reasoned that, since water cannot float rocks, the only current capable of transporting them would be one that moved at an enormous velocity, faster in proportion to every increase in the weight of the rock. To roll some of the heavier boulders along, the current must have been rushing at a rate absolutely beyond the bounds of experience. He was told that natural forces may have acted differently in prehistoric times. His reply was that all the evidence we have seems to show a persistent *uniformity in the action of natural forces,* that accordingly science is bound to explain the past by invoking forces which, acting as they act at present, would be capable of bringing about the same results.

Some of the Plutonists supposed that the boulders might have been projected from the craters of volcanoes and thus have arrived upon the tops of hills or in lands of alien formation to their own. But Lyell showed that boulders bear the marks of grinding and not those of fusion, also that many are found far beyond the farthest probable range of any volcano. In a neat chapter that treats "Of the Supposed Former Intensity of Igneous Forces," he shows that volcanic power can and does upheave the crust of the earth most efficiently without violent eruptions or cataclysms.

His own explanation of boulders was original and ingenious, and almost right. He supposed that icebergs had travelled over a great part of the Northern Hemisphere, carrying stones of various sizes and shapes and dropping them as the ice melted. Not long afterward his iceberg theory gave way before the idea of vast glaciers in a universal ice age, an idea that Lyell himself was among the first to welcome. It was indeed not a denial but rather a development of his own hypothesis.

Above all, however, what Lyell achieved was to state and demonstrate what came to be known as the *doctrine of uniformitarianism.* This ungracefully named thought simply means, as Kingsley said, "that the laws which we see at work around us now have been most probably at work since the Creation." Kingsley, a priest of the Established Church, phrased it thus: a more purely scientific statement would end—"at work at all times." Like most important revolutionary principles, this is so simple, so clear, and so inevitable that one is forced to wonder at its not having been known all along. Hutton, years before, had declared that "a theory which is limited to the actual constitution of this earth cannot be allowed to proceed one step beyond the present order of things." If his books had been widely and deeply read, it might have been realized (as it was later realized by Huxley) that "so far as the not-living world is concerned, uniformitarianism lies there, not only in germ, but in blossom and fruit." Unfortunately, however, Hutton was not a skillful writer. His desire never to make a statement that might be inaccurate rendered his work cumbrous and hard to read. Besides that, he lived and died before catastrophism had a name or a real existence. To insist upon, to prove, and to enforce the idea that "the past must be explained by the present" was Lyell's great work, a work necessary to any real progress in the comprehension of nature. Without some such principle as a guide,

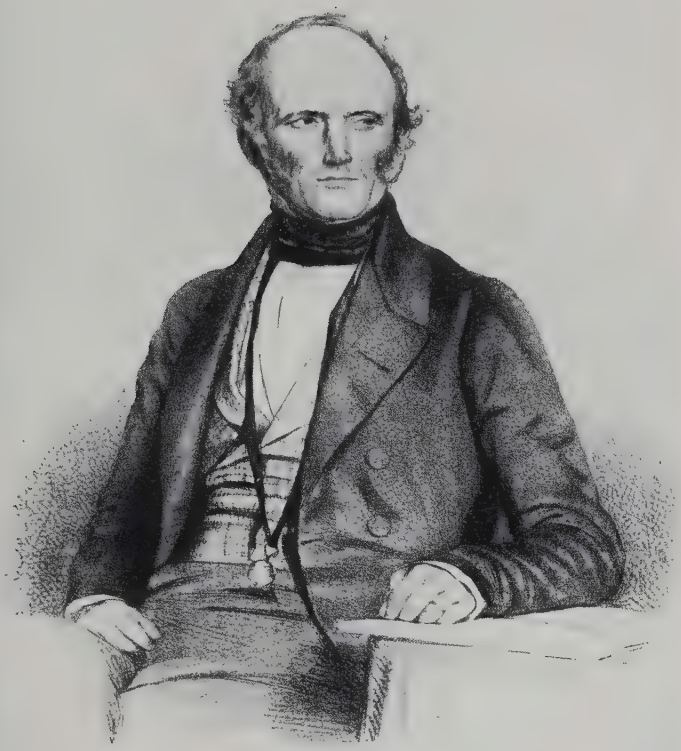
there is no limit to the fantastic character of possible theories. Under the direction of such a principle, science grows more and more into "organized common-sense," intelligible to every normal man who will take the trouble to study it, and provable by every trained man properly equipped. Uniformitarianism eliminates magic and superstition from science. In the widest application of the term, it is really the basic principle in all the study of natural phenomena, for it finally boils down to this: *identical causes, if the surrounding circumstances are identical, always produce identical results.*

There is one branch of knowledge in which it is never possible to postulate identity—the study of life. Lyell himself did not upset the current belief in the permanent fixity of species, though he came close to doing so and thus "was the chief agent for smoothing the road for Darwin." It will be recalled that he defined geology as "the modern changes of the earth and its inhabitants," thereby almost saying that the inhabitants of the earth had been changed. Yet his theory of progressive development of organic life at successive geological periods did not imply—at least not intentionally—the actual development of one species into another. But as Lyell did not believe in a universal catastrophe at the end of each great age, he did not fall into the usual absurdity of supposing successive destructions and recreations in each age of those lowly organisms which lived long ago and are still to be found.

Lyell was most fortunate in his temperament, which charmingly suited the best elements in the spirit of his age. He was neither a reactionary nor a radical, neither an unworldly laboratory-beagle like Darwin, a defiant revolutionary like Huxley, nor an embittered idealist like Butler. With grace and tact worthy of Lord Chesterfield, he combined rare learning, originality and force of intellect, literary gifts of no mean order, and a balanced sanity

that was most British and most genuinely Victorian in being at once courageously honest and quietly cautious. His book went far enough to stimulate and hearten the progressives, far enough to flutter but not to overturn the dovecotes along the Cam and Cherwell. Perhaps this is why Lyell lived a happy and hearty life, his mind active and receptive of new ideas even in old age. Perhaps this same moderation of his explains why his work is now less famous than its own intrinsic value might lead one to expect.

Indeed it was he who locked the rising arch of science with the keystone that it needed. Without the idea of uniformity, science was bound to be unstable, ready to sway or topple before every gust of fancy or superstition. But that idea did not remain long in the laboratory. Within a score of years it had penetrated many branches of literature under the names of "realism" and "naturalism." Lyell had removed the capricious element from our theories of nature. Zola and Reade and George Eliot did the same for our view of human life. Even Carlyle—of whom Darwin said, "I never met a man with a mind so ill adapted for scientific research"—even Carlyle held fast to the spirit, if not the letter, of uniformitarianism. His "lying is not permitted in this universe" is a most uniformitarian principle strangely interfused with mysticism. Carlyle's faith was not in the picturesque and miraculous, but in the invariable character of moral law. Fate as a philosophical idea was not the invention of Lyell. It is found in English literature at least as far back as Beowulf, which contains the proverb, *"Gæð ā Wyrd swa hīo scel"*—Fate goeth ever as she must. Yet the old picture always showed Fate as a determined old woman, or a determined old deity, deciding arbitrarily what must happen in the life of some human hero. It was uniformitarianism in a sense, but it was full of loop-holes, of individual variations and quiddities. Scientific uni-



SIR CHARLES LYELL

formitarianism is far more consistent, impersonal, intelligible, uniform. In the field of physical science, of number, motion, and force, it had been implied at least since Isaac Newton propounded his three laws governing the motion of material bodies. Yet Lyell was the first to state the doctrine explicitly, to found his system of thought upon it, and to apply it to the less predictable, less calculable operations that are described by the natural sciences.

When the first volume appeared, in the eventful summer of 1830, it was variously greeted. An anonymous critic—probably Poulet Scrope—in a long and enthusiastic article in the *Quarterly Review,* hailed its appearance with the greatest satisfaction, predicting that it would "mark the beginning of a new era in geology." The reviewer strikes out manfully against "those well-meaning persons who have thought fit to fight the cause of religion by assailing such as are really amongst her most effectual supporters"; he reminds us "that the discoveries of Newton are yet, in some Catholic states, accounted rank heresy"; he warns all "of the danger and impropriety of bringing the discovery and arrangement of facts, in the physical sciences, into competition with subjects of faith." Lyell himself was a little concerned over this development, for the power and determination of the Established Church—and its official attitude—had but recently been displayed. Dean Milman's "History of the Jews" had appeared about a year earlier. Its objective discussion of the events of biblical history, its frank and even cavalier treatment of the most respectable scriptural worthies had aroused opposition and had done immeasurable damage to the dean's career. "I trust," wrote Lyell just before the "Principles" appeared, "mine will be thought quite orthodox. At all events the bishops cannot stop my promotion, as they certainly will Milman's."

Other eminent geologists upheld the hands of Lyell.

Adam Sedgwick, who occupied the chair of geology at Cambridge and whose learning and personal power shed an influence over many minds including Darwin's, became a zealous convert, throwing "overboard all the diluvian hypothesis; vexed he ever lost time about such a complete humbug," though he never quite accepted the central principle.[5] Professor Gideon Mantell, who belonged to all the learned societies and wrote and lectured prolifically and impressively—for children, specialists, or persons of culture or of no culture—took over the uniformitarian idea without reservation. In all his work of later date than 1830, the impress of Lyell's thought is unmistakable. Sometimes, as in "The Geology of the South East of England," the reference is direct; here he calls Lyell's "Principles" "a work that places its author among the most distinguished of modern geologists," and he denominates the Lyellian exposition of climate "luminous —admirable—beautiful." Sometimes the influence of Lyell is implicit rather than expressed, as when Mantell attacks the diluvian school, bidding us "dismiss from the mind all prejudices, from whatsoever source they may arise."

[5] See his "Presidential Address to the Geological Society," 1831.

CHAPTER IV

OTHER MEN AND LATER YEARS

Not all the world went Lyellian at once. Some men refused to be convinced, and some modified their views by easy stages. One such geologist, whose view was changed gradually and who carried multitudes with him, was Sir Henry T. De la Beche.* Early in life he formed two contacts which gave him a wide sphere of influence. One was the government service, the other Charles Knight of the Society for the Diffusion of Useful Knowledge.[1] That society, destined to play a significant part in the intellectual spreading out of the succeeding years, had been established shortly before under the erratic ægis of Henry Brougham. That most versatile of statesmen had given the society an impetus toward scientific publication by his stirring, popular pamphlet, "A Discourse on the Objects, Advantages, and Pleasures of Science"—an undistinguished, unoriginal, slipshod essay which had nevertheless an immense influence for good.

Charles Knight remained the active director of the society's publications. One of his darling schemes was a series of books on "How to Observe," intended to introduce to mechanics and clerks the methods of science. De la Beche was chosen to write the volume on "How to Observe Geology." This book, its author's first venture into the field of popular writing, made its appearance in 1835. It was a good book in its day and generation, obviously popular, elementary, and simple, yet not cheap nor weak nor sentimental. It concedes in form but not in

* (1796-1855.)

[1] For further discussion, see Chapters IX and XXI below.

subject-matter to the admitted ignorance of its readers, and is so framed as to be a ready starting-point for further study. In this book De la Beche adopted a logical, essentially deductive method of presentation, which he continued to use in later writings. Much concrete illustration, verbal as well as in the form of woodcuts and geometrical diagrams, makes seeing—which is believing—easy. Yet there is one outstanding fault: De la Beche in writing seems always conscious of the ignorance of even the greatest geologists, and again and again he suggests methods of observing phenomena that in the '30's had never been properly studied. Naturally the book is overloaded with the technique of geologizing, and not proportionally rich in actual earth-lore.

Later he recast "How to Observe Geology" into "The Geological Observer" (1851) in which the virtues but not the faults of the earlier book are preserved. Even before the earlier one, he had begun to work on a less popular volume, which appeared in 1834 as "Researches in Theoretical Geology," an excellent example of careful scientific reasoning and logical presentation of theories which too often could not be tested directly.

Now, an inspection of De la Beche's works in *the order of their appearance* shows us a great deal as to the slow progress of Lyell's ideas. The book that was published earliest contains scarcely any mention either of Lyell's name or of his teachings. On the contrary it seems to presume that catastrophes of great extent occurred on earth, causing the extinction of all life. Nor is it strange that he should have held this view: he had collaborated with Conybeare—a die-hard diluvian, of whom more anon—upon a study of the newly discovered plesiosaurus. In that paper (*Transactions of the Geological Society, 1821*), which, though written by Conybeare, bears the name of De la Beche as co-author, the strongest vituperation is poured upon the iniquitous folly of Lamarck and

his followers for their theory that living animals, and possibly man himself, are the modified descendants of extinct creatures. De la Beche, when not collaborating, was better balanced, more reasonable, less immoderate. His later works in the order of their appearance show an increasing, though never quite complete, acceptance of the ideas expressed by Lyell.

Naturally there was great opposition to Lyell's theory. Some great names were ranged against it. Baron Cuvier, though he had entertained Lyell at his scientific salon in Paris and might have been considered as a friend, did not hesitate to condemn doctrines so irregular, and, with the doctrines, the man who professed them. Buckland, Lyell's old teacher at Oxford, was temporarily silenced, but as soon as possible he set about a refutation. It will be remembered that Buckland's "*Reliquæ Diluvianæ*" was one of the classics of the catastrophic doctrine. Lyell thought that nothing but the need of consistency kept his master and friend upon the old path.

In 1836 Buckland's treatise on "Geology and Mineralogy" was published under the foundation of the Earl of Bridgewater. The noble earl, who was also a clergyman, had died in February 1825, leaving a bequest of £8000 to provide for the publication of books "on the Power, Wisdom, and Goodness of God, as manifested in the Creation." Evidently of the school of Paley, he had further suggested "illustrating such work by all reasonable arguments, as, for instance, the variety and formation of God's creatures in the Animal, Vegetable, and Mineral Kingdoms; the effect of digestion, and thereby of conversion; the construction of the hand of man, and an infinite variety of other arguments; as also by discoveries, ancient and modern, in arts, sciences, and the whole extent of literature." Thus in his last will and testament did the Right Hon. and Rev. Francis Henry, Earl of Bridgewater, provide, sensing doubtless a vast

and righteous force within his grasp; but all he achieved was a temporary flourish. Some of the most respectable scientific scholars of the day wrote their least significant works as Bridgewater treatises. Pegasus—even the scientific one, it seems—cannot be hired except without his wings. Sir Charles Bell wrote on "The Hand: Its Mechanism and Vital Endowments as Evincing Design," and other treatises came from the pens of Dr. Chalmers, Dr. Whewell, Dr. John Kidd, Dr. Peter Mark Roget, Mr. Kirby, Dr. Prout, and—to complete the cycle—Dr. Buckland, the geologist. Buckland's purpose was to vindicate the ways of God to man; somehow, like many another in every age, he felt that this could be done only by upholding old theories and opposing new ones. Conybeare also, though he did not write on the subject, continued to repeat the catastrophic doctrines that he had held all along, and used the weight of his influence to prevent the belief in uniformitarianism from growing.

Perhaps the most remarkable figure among the geologists of the time was Sir Roderick Impey Murchison,* a man of immense and varied powers. Trained for a military career, he had actually served in the Peninsular War as a captain of dragoons and in middle life turned to the study of the earth with rare but curiously unstable achievement. In the intervals of a vigorous fox-hunting life, he made numerous important discoveries, establishing himself as an authority in geological science. Hearing rumors of a shifting coast-line along the northern rim of Sweden, he journeyed there and made the first scientific observations of that important phenomenon. Thence he wandered eastward and, with a Frenchman and a German (de Verneuil and Keyserling) for the first time systematically studied the very illuminating structure of Russia. After Perm, a province of the czar's empire,

*(1792-1871.)

he named the Permian system of rocks, never before called to the notice of geologists. He also named the Laurentian and Silurian systems after the St. Lawrence and an old tribe in Wales respectively. The latter discovery occasioned his two best-known works—"The Silurian System," published in 1838-9, and "Siluria, The History of the Oldest Known Rocks Containing Organic Remains," which was not given to the world until 1854. Yet even in the last-named book, which first appeared after Lyell's had attained its majority and become a classic authority, Murchison shows himself less than half persuaded. He contrasts "processes now going on in nature on a small scale" with "those infinitely grander ancient metamorphoses"—almost a direct denial of uniformitarianism. And again he states that "Geology . . . has revealed to us that during cycles long anterior to the creation of the human race, and while the surface of the globe was passing from one condition to another, whole races of animals—each group adapted to the physical conditions in which they lived—were successively created and exterminated." Yet he had travelled and worked with Lyell and must have known his views. It was of the same Murchison that Charles Darwin wrote, "How singular so great a geologist should have so unphilosophical a mind!" Perhaps his curious obtuseness in this question must be laid to the same mental poverty.

The problem of species was definitely raised by Lyell in the second volume of his "Principles," which was published in 1832. He came to some startling conclusions—notably that the organic world now is, and has always been, in progress. Nevertheless his discussion of the evolutionary theory of Lamarck is a scholarly and well-reasoned refutation. The idea that certain "appetencies" existing in all living creatures enable them to develop the organs they need seemed to him entirely chimeric, so, in

the absence of a *vera causa* for the natural development of species, he remained an upholder of separate creation. This moderation doubtless helped to soften the sting which every new theory bears behind it and to make the acceptance of uniformitarianism a less painful process than it would otherwise have been. Yet Lyell did not share the view commonly held, and expressed by Murchison in the words quoted above, that races of animals "were successively created and exterminated." To him, the extinction of species was going on all the time, and so was the "creation" of new species. Thus, in all points but one, he had practically stated an evolutionary system.

By the time the second volume appeared, the battle of uniformitarianism was won. Or it might be more correct to say that the opposition had collapsed. Some of the upholders of the catastrophic philosophy, with better or worse grace, walked over to the new army. "Whewell at Cambridge," wrote Lyell, "has done me no small service by giving out at his university that I have discovered a new set of Natural powers which might be termed 'geological dynamics.' He is head tutor at Trinity and has more influence than any individual, unless it be Sedgwick." Others felt even the partial influence of Whewell and fell into line. Honors and recognition came to Lyell, sometimes with odd indecisiveness, as when the Royal Society awarded him a medal for his work but carefully withheld any official opinion as to the correctness of disputed matters contained in it. He was elected to fill the chair of geology at King's College, London. The committee that chose him included several bishops, and even the lay members were men of undoubted orthodoxy. Yet "the prelates declared" (to quote from another of Lyell's letters to one of his sisters) "that they considered some of my doctrines startling enough, but could not find that they were come by otherwise than in a straightforward manner, and . . . there was no reason to infer that I had

made my theory from any hostile feeling toward revelation." Even Conybeare, after he had "fired a shot" [2] at the new hypothesis, wrote to the committee recommending its author.

So he became Professor Lyell, the thoroughly respectable authority on geological science. Long afterward, old men like Murchison still repeated the customary catastrophic formulas of their heyday. As late as 1857, and again in his second edition in 1866, a lone eccentric scientist such as Colonel George Greenwood might name his book "Rain and Rivers, or Hutton and Playfair against Lyell and All Comers," adding that "the once sane Lyell has gone into all the insanities of glacialism." These are rarities. Even Murchison tried as well as he could to adopt some part of the uniformitarian concept.

The book was a popular success as well. It sold rapidly and steadily. Before the third volume was issued in 1834, the first two had been republished, so that what was given to the world as the third edition was in reality the first complete one. Early in his career, Lyell had been told (by John Murray, the publisher) that his book might prove to be "an annuity." In actuality, it became a life-work as well. Editions were constantly being exhausted and new editions demanded. Lyell was an open-minded searcher for knowledge, ever abreast of, or ahead of, the science of the time. Whenever he authorized a new issue of his work, he revised it thoroughly, making the later edition a reliable contemporary treatment of a subject that can never be antiquated. He changed the form of the book, as well as the contents, turning it into four volumes or into two, as seemed best at the time. When the glacial theory was expounded by Louis Agassiz—who had got it at two removes from an Alpine chamois-hunter named Perraudin—Lyell dropped

[2] Like the other quotations, this is from the "Life and Letters of Sir Charles Lyell."

his icebergs abruptly and adopted the notion of a completer ice epoch as part of his total body of thought. After evolution had proved itself to his own conservative satisfaction, he modified parts of his book—including even the title—to allow for the altered picture of the cosmos which this involved. Thus the successive editions of the "Principles" form in themselves a series of most important original documents concerning the history of geological science during the middle half of the nineteenth century. He had barely finished revising his book for its twelfth incarnation, when his death occurred in 1875.

Besides working over the "Principles of Geology," he wrote several other geological books and seventy-six learned papers. His "Elements of Geology" (1838), "Manual of Elementary Geology," and "Student's Elements of Geology" (1871) show the same grasp and the same literary skill as his greater work; the first rapidly became a standard treatise, and the two others were popular books of considerable appeal. As to his second masterpiece, "The Antiquity of Man," discussion must be reserved until the story of evolution is given. Besides these, he wrote accounts of his two voyages to America, including geological observations.

Intellectual changes tend to take place slowly. The great catastrophe is no more true in the cultural world than in the world of matter. Thus the idea of uniformity as a complete and governing power was not established except gradually and partially. Nevertheless in the early '30's and with a minimum of broken heads, Lyell had successfully presented and upheld that idea. Its highly scientific character was widely recognized. Men's understanding of their world, of their lives and the meaning of life, was bound to be altered, however subtly and unspectacularly, by this changed manner of looking at the universe. Poulet Scrope said that if Lyell's theory were generally accepted, science would advance at one

bound as much as in fifty years. It was accepted, and the advance followed. Interesting and valuable as Lyell's work is in itself, it becomes noteworthy chiefly as the great forerunner of more startling things that were to follow. It had made possible a greater freedom of thought than hitherto; it had supplied much of the material of new and more ambitious thought, and it had devised the tools by which realistic thinking might be accomplished.

The stage was set for another, vaster development, one more stirring to the human imagination, and for the inevitable conflict that accompanies every advance.

PART II

THEORIES OF EVOLUTION

Nowhere is it possible to draw a line and say, here science begins.

Scarcely any change can rightly be ascribed to one agency alone.

Herbert Spencer.

To think is to theorize.

Erasmus Darwin.

Until science is mixed with emotion, and appeals to the heart and imagination, it is like dead, inorganic matter; and when it is so mixed and so transformed, it is literature.

John Burroughs.

I find no difference but only in magnitude between the Cat of Europe and the Ounce of India.

Sir Walter Raleigh.

Those were the days before "Natural Selection" had been discharged into the waters of the evolutionary controversy like the secretion of a cuttle-fish. Changed circumstance immediately induce changed habits and hence a changed use of some organs and disuse of others: as a consequence of this, organs and instincts become changed, and these changes continue in successive generations.

Samuel Butler.

In respect to other things there may be times of darkness and times of light; there may be risings, decadences, and revivals. In science there is only progress. . . . What is gained by scientific inquiry is gained forever; it may be added to, it may seem to be covered up, but it can never be taken away.

Sir Michael Foster.

And as we are fond of everything with which custom hath acquainted us; so on the other hand we start and boggle at every unusual appearance, and cannot endure the sight of the bug-bear Novelty. On this account very innocent truths are often affixt with the reproach of Heresie; and made terrible things in the imagination of their misinformed and frighted enemies.

Joseph Glanvil.

CHAPTER V

TO THE GRAND CENTURY

History repeats itself, and nowhere is this generalization more strangely true than in the history of science. Suppose, for example, that one of the Tennessee jurors who in the summer of 1925 convicted Mr. John T. Scopes of the crime of teaching "a theory of evolution," were to pick up a copy of Washington Irving's "History of New York." No doubt, such a juror (like most persons who are not biologists) has an idea of evolutionism as a new and rather daring theory, and of Darwin as a sort of "flaming youth" with radical tendencies. What would be his surprise, then, to find Irving in 1809 with tolerant irony mentioning "the startling conjecture of Buffon, Helvetius, and Darwin, so highly honorable to mankind, that the whole human species is accidentally descended from a remarkable family of the monkeys!" Need we tell him that the Darwin in question was a highly respectable physician and poet, who in the eighteenth century gave expression to ideas usually associated with the name of his grandson?

But he was not the first to hold theories of this type. During the life of Julius Cæsar, Titus Lucretius Carus, the most gifted philosophic poet of all time, produced an essay on the world, nature, and life. This elaborate Latin poem, *"De Rerum Natura"*—"On the Nature of Things"—is declared by the poet to be merely a restatement of the unpublished remarks of Epicurus. It is strangely modern in many ways; in its tone of disillusion, its scorn of superstitions even of the most aristocratic forms, its cold passion for reality. Above all, it expounds

three scientific theories, the atomic, the nebular, and the evolutionary, all three of which, after long submergence, have come to the fore almost in our own day.

Even Epicurus may not have been the very first to mention this idea. Recent explorations have brought to light Sumerian tablets whose legends seem to tell of a former time "when men walked on all fours and were beasts." Thus the shocking notion which upset all thought and bewildered all thinkers a generation or two ago, the heresy that is being fought and legislated against to this very day, is as old as any human civilization. In a highly intellectual form, it has been part of Western culture since the days before the great folk-migrations first brought North Europeans out of their own barbarous environment.

Yet there is a difference between all earlier theories of evolution and the modern ones. The greatest thinkers of two centuries ago did not possess the working equipment nor the knowledge of elementary facts that belong today to the most commonplace of students. When they theorized as to the origin of the forms of life, they were indulging in more or less logical flights of fantasy which one might choose or reject and there was an end of it. Most persons at most times rejected the evolutionary idea for reasons of religion or sentiment or good taste. Furthermore, the scholarly mind is often a methodical one and loves to classify its belongings. The concept that all life is divided into certain kingdoms, subkingdoms, orders, families, genera, and species—each absolutely real and permanent—is a natural and highly useful aid to the understanding of nature. Without some such view in mind, early naturalists must have seen nothing but confusion in the universe or at least in the living part of it. Then, too, the thought of the classic eighteenth century tended automatically to view everything as fixed and immovable. Change was considered

as always unfortunate and quite generally as a violation of the permanent, invariable perfection of the cosmos. So when the great Linnæus (Carl von Linné, an eighteenth-century Swedish botanist)* classified all plants and animals, humbler savants accepted his nomenclature and his classifications and regarded it as settled for all eternity that such and so were the forms of life and such and so they would remain.[1]

Then came Buffon,† whose vast *"Histoire Naturelle, générale et particulière"* in forty-four sumptuous volumes was for half a century the leading scientific authority as well as a best selling favorite of dependable popularity. Buffon was not only learned but shrewd as well; his work contains meat for the mastication of specialized jaws, spice for the delectation of the vulgar palate, and caviar for the subtler sensibilities of the intellectual élite. To appreciate Buffon justly one should have a three-speed mind, able to shift at a moment's notice from high into low or even into reverse. Thus a great part of his writing is accurate and authoritative, according to the best standards of his day, so packed with relevant information that many a naturalist must, when in doubt, have taken down the proper volume to use its statements as the *obiter dicta* of a supreme court. Yet Buffon treated his subject most humanly. He did not take up the animals in any order based upon natural affinity or classification, but rather in the light of their connection with ourselves. Thus, after his discussion of man, comes, not an account of the ape as man's nearest anatomical parallel, but an account of the horse, that "spirited and haughty animal, which shares with him the fatigues of war and the glory of the combat . . . , which renounces his being, does only what we wish, giving himself up without reserve, and

[1] Yet Linnæus himself advocated a modified theory of the origin of species by evolution from a few primitive types.

* (1707-1778.) † Georges Louis Leclerc, Comte de Buffon (1707-1788).

refuses nothing—makes use of all his strength, exerts himself beyond it, and even dies the better to obey us." [2] For, said he,[3] with praise-worthy frankness, "it is more easy, more agreeable, and more useful to consider things in their relation to ourselves than from any other standpoint." What a marvellous advertising psychologist that ancient Frenchman would have made! No wonder that the public devoured edition after edition of his books, so that (Shaw tells us), in the Dublin of fifty years ago, folk were still clamoring for "the works of the celebrated *Buffoon*."

Now if Buffon had chosen to present his animals not in relation to ourselves but in relation to one another, he would have been obliged to take some open position on the evolutionary question. Logic would have compelled him either to comment on the Creator's nicety in making species so much alike yet so distinct, or else to point out the easy intermediate steps by which one species can be seen to grade into another. By his method of human, rather than logical, classification, he evaded both horns of the dilemma.

Still it seems probable that his inclination was toward the evolutionary attitude. There are radiant vortices, purple patches scattered through his books, which may well have escaped both the ignorant and the educated, being intended only for the spritely. Of course, Buffon, like all prudent Gauls before the Revolution, was a good Catholic. He says so himself, so it must be true. Naturally he was hard put to it to refute the absurd cosmogonies of Whiston, Woodward, and Burnet who (in explaining fossils) tried to harmonize observation and revelation by supposing "that in the time of the flood there was a total dissolution of the Earth." [4] The sly old count comes through with all pennants flying. Says he, these men are infidels for trying to explain a miracle as

[2] Dublin ed. (tr.) p. 71. [3] Tome 1, p. 34. [4] Tome 1, p. 183.

due to natural causes and not to the will of God; there never was any conceivable natural cause competent to bring on the deluge, which likewise had no geological effects recorded in Genesis. Therefore, the whole episode is to be excluded from our reasonings about the Earth—and, beating the bass-drum lustily for the literal interpretation of Scripture, he proceeds to set that whole matter on one side and to form his own system as completely and as complacently as though he had denied revelation altogether. Ironically he touches on that wicked theory of evolution, giving it a beautiful and keen demonstration, then adding (as if to disarm the Augustan fundamentalist): "Does not such a consequence, I ask, prove repugnant alike to religion and common-sense?" In discussing the goat, he leaps to a wholly unnecessary tale concerning hybrids and the question of whether a half-breed belongs to its father's species or to its mother's or to an entirely new one, not listed among those to which Adam gave names.

Now, like many another, Buffon was led by his excessive smartness into sundry tight places and he had to call upon the same wit to get him out again safely and with prestige uninjured. Though he was of the nobility, though he dedicated his work to the King, by whose orders (declares the prefatory epistle) it was undertaken, he had gone too far. Accordingly, in 1751, the Syndic of the Faculty of Theology addressed to him a very courteous but unmistakable message, citing fourteen heretical statements culled from his early volumes and "giving vast eulogy to his so Christian resolution" to remove the stain by further elucidating his real beliefs, at the same time demanding that he "prepare himself to execute it." The quotations chosen by the Syndic do not concern evolution; in fact, the zoölogical portion of "The Natural History" had then not yet been published. They deal with the future extinction of the sun, with the description

of the soul, and with certain philosophical abstractions touching the nature of truth.

Outdoing his accusers in politeness, Buffon replied in such manner as to disarm all criticism. He thanked the Faculty of Theology for having given him an opportunity to explain the rectitude of his intentions; he offered voluntarily, if the gentlemen of the Faculty should so desire, to publish his explanations in his very next volume, and he remained with respect their most humble, most obedient servant. And his explanations? Wise they surely were and destined to serve their purpose of turning away wrath, answers so soft as to be almost lacking in manliness. He had had no intention, declared this foremost naturalist of the day, to contradict anything in the Scriptures: "I abandon all that in my book, which regarded the formation of the Earth, and in general all that which could be contrary to the narration of Moses, having" (adds this shameless hypocrite) "presented my hypothesis on the formation of the planets but as a purely philosophical supposition." How he must have chuckled as he penned those lines! And his theory of truth, said he, concerned only common facts of the vile material world; he did not mean it to apply to the revealed objects of faith, "an order of verities which I expressly said I should not speak of, since my subject did not require it."

Needless to say, it worked. Here was no crude radical, no incendiary, atheistical revolutionist, preferring his own wicked ideas to good taste, good morals, good government, or even to his very material welfare, but a gentleman born and bred, courteous, even courtly, deferential to Authority, and, besides that, the King's appointee and protégé. What if his recantation did hold a quibble or two; one can always shut an eye. Or, perhaps, the Deputies and the Syndic, learned though they were and skilled even in the splitting of hairs, never saw the quib-

bles. At any rate his explanations were read at the "particular assembly" and then at the "general assembly on the first of April, 1751, which, after hearing the reading, accepted and approved them."

Thereafter the count's attitude toward all possible heresies changed noticeably. He had learned what kind of remarks would invite attack; he had learned also how to defend himself. He became more cautious, but bolder also, with the self-assured daring of the experienced adventurer who knows to the last scruple how far he can safely set his foot, when and how he must provide against danger. One favorite method now adopted was to present his own ideas, seemingly to refute them. Though he asserts that this or this theory is "manifestly contrary alike to religion and good sense," one who reads for flavor and color and psychological tone can readily sense that the author's preference, even his enthusiasm, is on the side of the theory, which is so warmly expounded and then so stiffly, so officiously condemned.

It is under this disguise that Buffon's best, most comprehensive statement of the evolutionary hypothesis is insinuated into our notice. The horse has been most brilliantly described, his life, his habits, and his relation to man narrated, and we are to hear of the ass. Buffon begins: [5] "To consider this animal, even with attentive eyes and in sufficiently great detail, it appears to be nothing but a degenerated horse." After this introduction, he details a dozen "perfect similitudes" which "seem to found that opinion; one could attribute the slight differences that are found between the two animals to the very ancient influence of the climate, of nourishment, and to the fortuitous succession of a number of generations of small wild horses, which little by little would always have degenerated more, which would finally be degraded as far as possible and in the end would have pro-

[5] Tome 4, pp. 377*ff*.

duced before our eyes a new and permanent species of the same class and different enough from the horses to be able to be regarded as forming another species." In support of this idea, he cites the great variability of horses as to color and other characteristics, the small size and donkey-like gray color of wild horses, and so on.

From this spring-board, he leaps into a discussion of the whole question of the origin of closely related species, "which demands that we consider Nature under a new point of view." For, however much all animals "vary by differences grading off into infinity, there exists at the same time a primitive and general design" for all; the horse "astonishes by his singular and almost complete resemblance" to man. Indeed, as his collaborator Daubenton had remarked, a hoof is really but a finger-nail. This general design, taking in "man, the quadrupeds, the cetaceæ (or whales), birds, reptiles, fish, etc., in which the essential parts are always found, seems to show that, in creating animals, the Supreme Being wished to use but one idea and to vary that at the same time in all possible ways, so that man might admire equally the magnificence of the execution and the simplicity of the plan."

"In this point of view not only the horse and the ass, but even man, the ape, the quadrupeds, and all animals could be regarded as forming but one and the same family" containing "other smaller families produced by time. . . . If one admits this, it could be said likewise that the ape is of the family of man, that he is a degenerated man, that man and ape have had a common origin like the horse and the ass . . . and even that all animals have come from one animal, which, in the course of time, by perfecting itself and by degenerating, has produced all the races of other animals."

In this rather lengthy digression, well-nigh the whole scheme of evolution is outlined, and it seems to be a

genuine expression of the author's view. However, the burnt child learns to dread fire, so a bit further we read the recantation of a chastised naturalist. "But, no, it is certain, by revelation, that all animals have shared equally in the grace of creation, that the two first of each kind came forth fully formed from the Creator's hands." This, of course, is not argument but a declaration of faith and probably not the faith of him who wrote it. The arguments with which he sustains it are cold and unimpressive; for instance, that man has never seen one creature turn into another, that interbreeding produces sterile offspring. Some of the arguments might be quite as applicable on the other side as on that which he purports to favor. Thus he denies the entire existence of species and of families, which "are our work, which we have made merely for the comfort of our own minds. . . ." " . . . Therefore," concludes Buffon, "the ass is an ass and is by no means a degenerated horse, a horse with a shaven tail . . . as humble, as patient, as tranquil as the horse is proud, ardent, impetuous."

In scores of other discussions, the traces of an evolutionary turn of mind can be recognized. Wheat, we are told, has been transformed by man to what it is, having so far changed from some original wild prairie-herb that it is impossible to say positively just which of the native grasses was its true progenitor. Likewise the wild dogs of Africa and America differ from wolves only in their greater adaptability; it is the work of man that has made the dog the faithful domestic creature that we know and which has developed a great many varieties out of but three or four. In thus recognizing the purposive selection of certain types by breeders as a means of evolution, Buffon definitely foreshadowed the more important part of Darwin's experimental work. He even came near to recognizing the struggle for existence and its resulting survival of the fittest, for he cites the tremendous fecun-

dity of all forms of life, held in check only by the action of natural enemies and of the environment. By this suggestion he anticipated the population theory of Malthus, which, as will be seen, supplied the long-sought needed step for Darwin's reasonings. Thus, in still another way, Buffon made himself the founder of evolutionary ideas.

For one whose work was done in a foreign language and lies wholly without the nineteenth century (for he died in 1788, and his forty-fourth and last volume was finished by others in 1803), Buffon none the less deserves much comment here. In the first place, his statement of the theory—however cloaked in equivocation—is the best, most affirmative, and most thoroughly sustained by facts which had then been produced. In the second place, of all who have written on scientific subjects, few if any have excelled Buffon as literary craftsmen. Antoine Auguste Renouard [6] declares that "one can learn natural history in many other works; but only in Buffon will one find those animated descriptions, that charm which he knew how to spread over the most arid topics, the most abstract reasonings, that infinite number of passages embellished with the most brilliant colors of true eloquence, and which are eternal models of style, living precepts on the art of writing."

Whether one should believe this extravagant editorial eulogy or the author's own more modest account of his work as a "few essays written without art or other ornament save that of nature," it is necessary to recognize in him a self-conscious and intentional artist. He constantly revised the style of his work and that of his collaborators.[7] The French Academy—that Table Round of the knights of the quill—elected him as one of their body, and the address he delivered upon his reception [8] among

[6] "Advertisement" to his edition of *"Morceaux Choisis de Buffon,"* Paris, 1830.

[7] Höhne, Ernst, *"Der Stil Buffons,"* p. 12.

[8] Buffon, *"Discours sur le Style,"* 1753.

them sets forth his own ideas on the technique of expression. It is from this "Discourse" that an oft-quoted, much misunderstood epigram comes; when Buffon said,—"Style is the very man," he did not mean that as a man is, so also will he write—individually, peculiarly—but rather that the facts of a book are its body and the style its soul, its human and living quality. A true child of the classic age, he believed in generalized expression, in a definite, attainable excellence in literature, not in any romantic sorcery of inspiration and individuality. "Style," said he, "is nothing but the order and movement that one puts into one's thoughts . . . one must know how to present them, to shade them, to order them. . . ." Good style is the result of thorough knowledge and meditation; it is restrained, balanced, proportioned, unified. It avoids cleverness and pomposity, seeks nobility through the use of general expressions. And, in conclusion, "well-written books are the only ones that will pass on to posterity."

So far went his rhetorical theory. In practice, of course, he was not so negative nor so prim as these ideas would imply. He wrote well, in accord with his rules, and even better when he violated them. Though he treated the most detailed and intimate portions of natural history, he managed to avoid vulgarity, but the "general expression" which he praises so was often displaced by a flood of concrete and very specific descriptive terms. He makes use of all the standard figures of speech, especially working the figure of personification, and even dips into unusual literary devices such as oxymoron. He appeals to the sensory imagination in all its forms—visual, audile, olfactory, tactile, and palatal. Although he hated nomenclature, he chose and used freely the most serviceable word, whether foreign or technical. Clarity is his first requirement—excellent doctrine for a scientific writer.

CHAPTER VI

DARWIN THE FIRST

It is usual to associate the name of Buffon with that of the eccentric and philosophical village doctor of Derby and Lichfield, Erasmus Darwin. That curious man was a younger contemporary of Buffon's, born in 1731.* He had none of the courtliness of the French count, but was rather a scientific counterpart of the hearty Dr. Johnson. All his life he practiced medicine in an unnoticed corner of England, and such distinction as he did attain crowned his poetic rather than his scientific work. A busy and successful practitioner, he wrote while going to and from patients in his coach, which he had fitted with a special writing-desk. None of his work was published until he was more than sixty years of age.

Dr. Darwin was a man of inquiring, progressive, independent mind. All his life he took a keen interest in mechanical invention and scientific discovery. A score of inventions are attributed to him, one of which—a very flexible one-horse gig—crippled him for life. In treating his patients, he often devised new cures or revived old and abandoned ones. Thus he was once upon the verge of a blood-transfusion to save the life of Lady Northesk. In two of his works [9] he recommended the use of powerful electrical shocks in the treatment of paralysis, and Miss Seward records that he sometimes used them to the notable benefit of his patients. Such electrotherapeutic methods have come into general use only during the past dozen years; even today, old-fashioned doctors still sneer

* (1731-1802.)

[9] "The Botanic Garden," Canto I, *Zoönomia.*

at them. He was a friend and admirer of Benjamin Franklin, whom he pictured in "The Botanic Garden" as mounting into the clouds and plucking thunderbolts out of the grasp of Jove. The scientific interests of that "first civilized American" attracted the doctor, who was charmed by Franklin's candor, simplicity, good sense, and intellectual courage. These were qualities that he shared and could appreciate, just as Johnson's obstinacy, absoluteness, and eccentricity—also parts of Dr. Darwin's personality—set up a civil feud between him and Lichfield's other, more famous, son.

That he was a competent and successful physician is evidenced by records showing the great extent of his practice. Patients came to him even from great distances; some were socially prominent, and some were themselves medical men. King George III intimated that he would make Dr. Darwin his personal physician, but a rooted fear of city air prevented his accepting this offer. He was acquainted with Rousseau and sympathized with the Frenchman's principles. Known as a skeptic, he was at first avoided by the *"unco guid."* Even this group, however, came to his door at last, for real danger to the body diminishes one's concern about the far less affirmative jeopardy of the soul. Incidentally, his "infidelity" was not vindictive nor scandalous. His works are crowded with respectful references to the Deity in most approved eighteenth-century manner—not highly enthusiastic, but evidently sincere and as dignified as the theological passages of Pope or Addison.

In 1784 he founded a Philosophical Society in Derby and thereafter occasionally wrote letters and addresses on scientific subjects. However, his fame as a writer depends in the main upon a few longer works, of a type now utterly outmoded but marked by the typical excellences of the author's mind; they were highly admired in their own day, and are certainly remarkable for vigor,

scope, and a happy knack of piercing the future. It is a curious contradiction that they present: cold, academic, pompous, artificial in their form, composed in the heroic metre and meretricious diction that even then had passed its prime, these didactic poems were strangely radical, realistic, and in every way forward-looking so far as their subject-matter or thought may be concerned. In "The Botanic Garden" the praises of the French Revolution are freely chanted, and the spirit of American independence is respectfully invited to set up its standard upon Irish soil. Hard words are levelled against the British slave-trade. And finally there is a clear, though ornate, exposition of the evolutionary hypothesis.

A quaint story of how he came to write this poem is told in Miss Anna Seward's "Life of Dr. Darwin." [10] "About the year 1777," begins this very female authoress, "Dr. Darwin purchased a little, wild, umbrageous valley, a mile from Lichfield, among the only rocks which neighbor that city so nearly. It was irriguous from various springs, and swampy from their plenitude. . . . The doctor cultivated this spot, 'And Paradise was opened in the wild.' . . . Not only with trees of various growth did he adorn the borders of the fountain, the brook, and the lakes, but with various classes of plants, uniting the Linnæan science with the charm of landscape."

Now one day, Miss Seward maintains, she went alone to this "botanic garden" of her medical friend and there, "seated on a flower-bank, in the midst of that luxuriant retreat, wrote the following lines, while the sun was gilding the glen, and while birds, of every plume, poured their song from the boughs:

> O, come not here, ye Proud, whose breasts infold
> Th' insatiate wish of glory or of gold. . . ."

and so on, through a meditation some forty lines in length, packed with Dryads and Naiads, Graces and

[10] Pp. 88*ff*.

Cupids, capitalized Taste and Virtue, Evening and Philomel. Of course it concludes by attributing its sentiments to "The Genius of the place," by whom, a footnote informs us, "is meant its first cultivator, Dr. Darwin."

She takes up the tale. "When Miss Seward gave this little poem to Dr. Darwin, he seemed pleased with it, and said, 'I shall send it to the periodical publications, but it ought to form the exordium of a great work. The Linnæan System is unexplored poetic ground, and an happy subject for the muse. It affords fine scope for poetic landscape; it suggests metamorphoses of the Ovidian kind, though reversed. Ovid made men and women into flowers, plants, and trees. You should make flowers, plants, and trees into men and women.' 'I,' continued he, 'will write the notes, which must be scientific; and you shall write the verse.'

"Miss Seward observed that, besides her want of botanic knowledge, the plan was not strictly proper for a female pen; that she felt how eminently it was adapted to the efflorescence of his own fancy."

So, after some further argument about it, the doctor took his friend's advice and proceeded to let his own fancy effloresce into both verse and notes. Just what might not be strictly proper for a female pen seems a somewhat doubtful question; but a little light was shed upon that subject when (in 1789) "The Loves of the Plants"—Part II of "The Botanic Garden"—appeared. The doctor was a great admirer of Linnæus' classification of flowering plants according to what is called "The Sexual System." He was a good observer and thought the great Swede mistaken in some details though broadly right even to inspiration. Carefully and rather elaborately, then, he catalogues a great many plants with reference to the Sexual System. But as this work is a poem in heroic verse, the plants are all personified, sometimes with scandalous results. At the bottom of each page,

bloated footnotes disgorge the unvarnished botanical facts which the upper half had presented in poetic trappings. For a taste: [11]

> The fell *Silene,* and her sisters fair,
> Skilled in destruction, spread the viscous snare,
> The harlot-band *ten* lofty bravoes screen,
> And, frowning, guard the magic nets unseen.
> Haste, glittering nations, tenants of the air,
> Oh, steer from hence your viewless course afar!
> If with soft words, sweet blushes, nods, and smiles,
> The *three* dread Syrens lure you to their toils,
> Limed by their art, in vain you point your stings,
> In vain the efforts of your whirring wings!
> Go, seek your gilded mates and infant hives,
> Nor taste the honey purchased with your lives.

And the footnote: "*Silene,* l. 139. Catchfly. Three females and ten males inhabit each flower; the viscous material, which surrounds the stalks under the flowers of this plant, and of the Cucúbalus Otites, is a curious contrivance to prevent various insects from plundering the honey, or devouring the seed. In the Dionæa Muscipula there is a still more wonderful contrivance——" which he goes on to explain altogether too lengthily. Sometimes the behavior of a flower will call to mind some classic fable or bit of medical lore, which is then promptly set forth, though at the cost of a digression, in both verse and prose. Hundreds of plants are characterized in this manner. There are four cantos with corresponding notes, critical interludes between cantos, and additional notes at the end. Yet "The Loves of the Plants" was published before Part I, because "the second part of his work would be more level than the first to the comprehension, more congenial to the taste of the general reader, from its being much less abstract and metaphysic . . . those [common readers] who had purchased the first part would not like to possess the poem incomplete, and therefore would pur-

[11] Canto I, line 139*ff.*

chase the second." And he solemnly gave out that he had put off publishing Part I until "another year, for the purpose of repeating some experiments in vegetation."

The deferred first part appeared in 1791. It is called "The Economy of Vegetation," a very poor title, for it not only has a repellent ring but does not fit the poem at all well. Of the four cantos, only the last is about vegetation, and that only in part. The whole poem is a vastly conceived poetic panorama of all science. There is so much symbolism, so much supernatural machinery in it that the reader, unless he be a student dowered with an iron resolution, is likely to sink, swamped under its bewildering profusion.

It opens with Miss Seward's meditation, after which the Goddess of Botany appears and addresses her cohorts: Sylphs, Gnomes, Nymphs, and a special group of Nymphs of Primeval Fire. These spirits represent respectively the four physical elements. To each species, she addresses a poetic oration, long and complex, packed with scientific lore relevant to that kind of spirit but not otherwise very systematic, and well supported by copious notes that often crowd from the foot of the page almost up to its neck. Near the beginning [18] we meet with a general statement of cosmic evolution.

> *"Let there be light"* proclaimed the *Almighty Lord,*
> Astonish'd Chaos heard the potent word;
> Through all his realms the kindling ether runs,
> And the mass starts into a million suns;
> Earths round each sun with quick explosions burst,
> And second planets issue from the first;
> Bend, as they journey with projectile force,
> In bright ellipses their reluctant course;
> Orbs wheel in orbs, round centres centres roll,
> And form, self-balanced, one revolving Whole.
> —Onward, they move amid their bright abode,
> Space without bound, *the Bosom of their God!*

[18] Canto I, l. 102*ff.*

This passage is not only a remarkable, short summary of an immense subject, so treated as to be at once theologically and scientifically acceptable, and even—despite changed taste—poetically imposing; not only does it show the author's familiarity with Herschel's then new "Observations on the Structure of the Heavens"; but it provides the occasion of the author's first remarks on evolution. In a note he tells us of the "gradual evolution of the young animal or plant from its seed or egg; and afterwards its successive advances to its more perfect state," adding that the world may be considered as a living thing, constantly growing (as Hutton was then preparing to prove). With the readiness and scope so characteristic of him, he applies this idea to life: "There are likewise some apparently useless or incomplete appendages to plants and animals, which seem to show that they have gradually undergone changes from their original state." After illustrating, he continues, "Perhaps all the supposed monstrous births of Nature are remains of their habits of production in their former less perfect state, or attempts towards greater perfection."

This canto, being addressed to the Nymphs of Primeval Fire, has little more that is to our immediate purpose, but it is full of interesting remarks. Among these are an address to Steam, including amazingly apt predictions of what it was to accomplish in the future, a short history of civilization as advanced through the use of fire, notes on volcanoes and the newly discovered gases and the *ignis fatuus,* which last he declares he never saw and therefore doubts, the gymnotus or electric eel, the Leyden jar, and the electrometer. It is here that he hymns the discoveries of Franklin and the death of Richman, a Russian investigator, killed in the course of his experiments.

Canto II is addressed to the Gnomes, and is accordingly rich in geological knowledge. Dr. Darwin understood limestone rocks to be made of the shells of extinct

creatures and regarded them as "mighty monuments of past delight." His method of personification seems to be carried too far in the figure of the adultery of Nitrogen and Oxygen, which starts him off upon a Homeric tale of Venus, Mars, and Vulcan.[13]

A third canto, treating of the powers of water, gives little more about plants or botany or evolution than those that have preceded it. The fourth, which is addressed to the Sylphs, takes up first the atmosphere and then those "daughters of air"—plants. It is here that the botanic muse begins to justify her name, for up to this point she had seemed more like a generalized patroness of all natural philosophy. The treatment here is quite the opposite of that employed in "The Loves of the Plants," which is little more than a versified catalogue; in this section general principles of plant life are propounded, and individual species are not mentioned save now and then in illustration of some great truth. Notes tell some of the doctor's favorite theories, such as that a plant is not a single organism but a colony of separate buds.[14] His poetry is at its best when he swings into the grand style, which this kind of writing amply encourages.

If a man is known by the enemies he makes, it may be fair to gauge the popularity of a book by the parodies it evokes. Probably no book has ever been more ably travestied than was Dr. Darwin's by an anonymous poem published in *The Anti-Jacobin* under the title of "The Loves of the Triangles." He had tried to reach sublimity in poetizing a science; his mockers went a step further and, by over-poetizing mathematics, attained that which is but one step from the sublime. His style is deftly

[13] For a modern retelling of this old myth, see "The Private Life of Helen of Troy," by John Erskine.

[14] He also maintained that plants can feel. In this he anticipated a descendant, the late Sir Francis Darwin, and the sensational experiments of Sir Jagadis Bose before the British Association in 1926.

imitated; similar metre—even to the overworked Alexandrine—similar heavy rubrics, footnotes, and a whole hierarchy of figurative machinery that is at once supernatural and hyper-mathematical, invite to laughter and to admiration. (It is recorded that the sportsmanlike old physician joined in most heartily.) Thus, to quote scraps from the canto-heading or "argument": "Nymphs and deities of mathematical mythology; sentimental union of the Naiads and Hydrostatics; Marriage of Euclid and Algebra—Nonsensia (the Didactic Muse). Love delights in angles or corners; . . . Dislocation and Contusion, two kindred fiends; exhortation to drivers to be careful. . . . Hippona, the goddess of hack-horses," and so on. In grandiloquent verse the stories of Jack Horner and Cinderella are told, each supported by a formidable array of footnotes. Some of these notes are triumphs of mockery; thus we find "Sulphur—a substance which, when cold, reflects the yellow rays, and is therefore said to be yellow." And again, there is this comment—upon "Young Volcanoes" in splendid Darwinian diction—"Those with which we are best acquainted are certainly not viviparous; it is probable that there exists, in the centre of the earth, a considerable reservoir of their eggs, which, during the obstetrical convulsions of general earthquakes, produce new volcanoes."

Undoubtedly the peak of this burlesque is that note which ridicules Darwin's theory of the evolution of all life from a single and simple "filament" and treats the evolution of the universe as but one phase of this process. Just as the doctor gave a biologically developmental explanation, his mimics gave a mathematical one: "We may conceive the whole of our present universe to have been originally concentered in a single point; we may conceive this primeval point, or *punctum saliens* of the universe, evolving itself by its own energies, to have moved forward in a right line *ad infinitum,* till it grew

tired; after which, the right line which it had generated would begin to put itself into motion in a lateral direction, describing an area of infinite extent. This area, as soon as it became conscious of its own existence, would begin to ascend or descend, according as its specific gravity might determine it, forming an immense solid space filled with vacuum, and capable of containing the present existing universe."

Years afterward the parody was acknowledged to be the joint product of Canning, Ellis, and Frere.

In the meanwhile, however, the good doctor had turned from tumid verse to scientific and vivid prose. In 1794 he published his professional masterpiece in two volumes under the title of "Zoönomia, or the Laws of Organic Life." This work had engaged his attention during twenty years and contains his most balanced and philosophic view of the real world and the problems of life as these had taken form in his mind during a long medical career. It must be recalled that in the eighteenth century medicine was scarcely a science but rather a skilled trade, based upon certain ancient writings, upon superstition, tradition, custom, and casual empirical experience. One could learn it by being apprenticed to any successful physician, just as one could learn to be a pastry-cook or a coach-builder. The great physiologists were not all doctors, and the majority of doctors were certainly not great physiologists.

Dr. Darwin had gathered much medical knowledge. Being a lover of theory, he had arranged his great stock of lore into an immense system of zoölogical philosophy, which the "Zoönomia" sets forth. His preface calls the book "an endeavour to reduce the facts belonging to Animal Life into classes, orders, genera, and species, and by comparing them with each other to unravel the theory of diseases." A medical student, by applying himself to that book, would not only harvest many practical hints

to use in the treatment of diseases, but would also shape for himself a cultural background linking his work with the related sciences—and with other learning as well.

In structure the book tends to be too methodical and almost entirely deductive in presentation. Parts I and II deal with General Physiology, Part III with Materia Medica; and in all parts the author follows the custom of laying down general principles first, then subdividing, and only as a last resort deigning to illustrate. Also he is too theoretical—a weakness which later sadly disappointed his grandson, who was a more determined observer and had more time for experiment. But the old doctor had a fine Augustan contempt for the over-meticulous. "To think is to theorize" was a favorite maxim of his. In the "Apology" to his "Economy of Vegetation" he declares: "Extravagant theories however in those parts of philosophy, where our knowledge is yet imperfect, are not without their use; as they encourage the execution of laborious experiments, or the investigation of ingenious deductions, to confirm or refute them. And since natural objects are allied to each other by many affinities, every kind of theoretic distribution of them adds to our knowledge by developing some of their analogies."

So he proceeded shoulderingly through his magnum opus, beginning with "the whole of Nature" and gradually working down to the cure for deafness and the proper diet for a consumptive. He wrote apparently from a well-stored, orderly mind, without immediate reference to notes or special experiments. (Indeed, what else could he do, writing in his jolting chaise?) His style, in the main, is calm and dignified, more so than we moderns like, but he breaks out now and then into some vivid and vigorous vulgarity, and quite often tells of his own patients, their ailments and (a trifle boastingly) of his

cures. In prose, as in his verse, he writes for the reader's *eye* with clear-cut, pictorial realism. He shows a decided interest in physical psychology—rare in that day—even discussing dreams from a sanely scientific viewpoint that the rest of the world has discovered only very recently.

It is in this book, likewise, that his best, most thorough, most rounded, and most balanced exposition of the evolutionary theory is to be found. His chapter on "Generation"—or reproduction, as it is now called—supplies the opportunity. He begins with the argument from *recapitulation;* that is, since each individual organism evolves from a single cell (or, in his wording, "filament") and grows to its mature state through forms that resemble other, simpler creatures, "would it be too bold," he inquires rhetorically, "to imagine that all warm-blooded animals have arisen from one living filament, which the great First Cause endued with animality, with the power of acquiring new parts, attended with new propensities, directed by irritations, sensations, volitions, and associations, and thus possessing the faculty of continuing to improve by its own inherent activity, and of delivering down these improvements by generation to its posterity, world without end?"

This brief summary is a far more thorough and philosophic statement of the idea of evolution, than had ever before been put into words. Buffon, even if we read between the lines, did not grasp all that his own ideas implied; and in his later writings seemed to withdraw to the rather conservative doctrine that species developed but that genera were permanent. However, Dr. Darwin —possibly because he was writing in anti-clerical England—worked out and very affirmatively presented a complete, consistent, rather detailed theory of the origin of all forms of life by means of evolution from a simple, primeval filament. The original filament, he supposed,

had come into existence spontaneously.[15] It contained much of what was later proclaimed by Lamarck and is usually known as Lamarckianism.

Briefly his explanation follows, so far as practicable, in his own words: [16] "All warm-blooded animals are derived from a single filament. . . . Owing to the imperfection of language the offspring is termed a *new* animal, but is in truth a branch or elongation of the parent [17] . . . and therefore it may retain some of the habits of the parent system. . . . The embryon is produced by the male and the proper food and nidus by the female." A word in explanation: he reasoned that if an offspring can inherit qualities from the mother, of which it is not a part, it can acquire hereditary qualities from any part of the environment as well. This suggests one of the questions still awaiting real solution.

Four years before Malthus' "Essay on Population," Dr. Darwin had grasped the essential idea of the pressure of too much reproduction and its bearing upon the survival of the fittest. He tells how "every individual tree produces innumerable seeds, and every individual fish innumerable spawn in such inconceivable abundance as would in a short space of time crowd the earth and ocean with inhabitants"—"which would perish in uncounted millions."

Now he turns aside to take up an idea current in his day under the name of "evolution," but almost unconnected with the subject of this chapter. That theory held that each seed or embryo contained in miniature the whole plant or animal that it was destined to become, into which it grew by a process of evolving or unfolding. Of course, then, it must contain the germs of all its

[15] Buffon also believed in spontaneous generation by means of a "Vegetative Force." For a thrilling narrative of how Spallanzani disproved this idea, see "Microbe Hunters," by Paul de Kruif.

[16] "Zoönomia," Sec. 39, pp. 373-443.

[17] Compare S. Butler, "Evolution Old and New," etc.

descendants to the last possible generation, a mediæval absurdity which arouses in the doctor a fine scorn: "They must possess a much greater degree of minuteness than that which was ascribed to the devils that tempted St. Anthony; of whom 20,000 were said to have been able to dance a saraband on the point of the finest needle without incommoding each other." And anyway, under that theory, there could be no mules. He did not add what must have been ramping in his mind, that under that theory there could be no evolution.

And here he cites Buffon's ideas, likewise his own objections to them. He did not feel that change was "degeneration," but rather progress; that the living creature or species grew and altered through the "accretion" of "new appetencies." He is very insistent on this point: "From hence I conclude that with the acquisition of new parts, new sensations, and new desires, as well as new powers, are produced . . . and this by accretion to the old ones and not by distension of them."

It is possible, he thinks with Linnæus, that a few natural orders may have been created, which by interbreeding have multiplied into the vast number of species known to us. He cites "the great changes introduced into various animals by artificial or accidental cultivation," with examples "which have undergone so total a transformation that we are now ignorant from what species of wild animals they had their origin." He tells of changed forms due to the "exuberance of nourishment supplied to the fetus, as in monstrous births with additional limbs; many of these enormities of shape are propagated and continued as a variety at least, if not as a new species." If he had only provided that such enormities must prove useful in the struggle for existence in order to be continued, he would have stated the chief doctrine of the later Darwinism; as it is, he managed to present half of it, or more.

The so-called principle of sexual selection or "law of battle" (which forms a great part of "The Descent of Man") is here neatly set forth: "The very thick shield-like horny skin on the shoulder of the boar is a defence only against animals of his own species, who strike obliquely upward, nor are his tushes for any other purpose except to defend himself. . . . So the horns of the stag are sharp to offend his adversary, but are branched for the purpose of parrying or receiving thrusts of horns similar to his own, and have therefore been formed for the purpose of combating other stags for the exclusive possession of the females; who are observed, like the ladies in the times of chivalry, to attend the car of the victor." It will be noted that he often asserts a kind of dogmatic teleology; that is, he can tell you off-hand for what purpose an organ has been formed. But he always remembered that the formation was gradual. Thus we read that "the nose of the swine has become hard for the purpose of turning up the soil in search of insects and of roots. The trunk of the elephant is an elongation of the nose for the purpose of pulling down the branches of trees for his food, and for taking up water, without bending his knees. Beasts of prey have acquired strong jaws or talons. Cattle have acquired a rough tongue and a rough palate to pull off the blades of grass." And so it goes. Obviously one principle of life governs all life; even the invertebrates—even plants—may be our relatives. "Shall we conjecture that one and the same kind of living filament is and has been the cause of all organic life?"

Erasmus Darwin thus anticipated Malthus, Lamarck, his own more famous grandson, Samuel Butler, Wallace, the neo-Darwinians, Mr. Havelock Ellis, and many others. He presents the argument from palæontology—that fossils are not exactly like their nearest living kin. He even tried to forestall the Fundamentalists by this argument:

"If we may compare infinities, it would seem to require a greater infinity of power to cause the causes of effects, than to cause the effects themselves," thus anticipating Paley and (later) Kingsley and Drummond and Fiske. He is, in short, a Great Anticipator. His work *proved* little, but, by a happy knack of shrewd guessing combined with rigorous reasoning, he hit off the general direction of much truth that was to be discovered later.

His next work in some respects is the most satisfactory one that he ever wrote. It is called "Phytologia; or the Philosophy of Agriculture and Gardening, with the Theory of Draining Morasses." It appeared in 1800 in one bulky quarto volume. This attempts to do for the vegetable world what "Zoönomia" did for the animal, and it shows that his art had benefited by experience and practice. His writing is more simple, more straightforward, as original, and perhaps based more often upon real observation. He shows the same ability to generalize, to connect all phenomena of one class, to extend a principle over an entire dominion or apply it with elastic promptitude to a special and detailed case.

Here, too, he discusses evolution, though, characteristically, with the greater moderation that marks this volume. The chapter on "Reproduction" has much to say of artificial breeding, especially through inter-breeding. He cites [18] the opinion of Linnæus, who supposed that the original creation had brought forth sixty plants, "corresponding to the orders, and that the orders by intermingling produced the genera, and these the species, and these the varieties in accord with the general progress of nature 'from simpler things to the more compound.' " And in discussing "Natural Orders," he suggests a classification based upon the *position* rather than the *number* of sexual organs of flowers, as being less susceptible to change. "This mutability or uncertainty,"

[18] "Phytologia," Sec. VII, 2, 8, p. 118.

he declares, "of the number of the organs of reproduction belonging to individual flowers, would seem to arise from an attempt of all organized beings toward greater perfection." Throughout this book he seems rather to assume evolution than to be engaged in trying to prove that it exists.

His last work, not published until after the author's death, "does not pretend [19] to instruct by deep researches of reasoning; its aim is simply to amuse by bringing distinctly to the imagination the beautiful and sublime images of the operations of Nature"; significantly he adds, "in the order, as the author believes, in which the progressive course of time presented them." Like "The Botanic Garden" here is another versified compendium of universal knowledge, more aptly named and somewhat less extravagantly elaborated. Its scope is even more all-embracing, for in the standard four cantos it relates the origin of life and of society, the progress of the mind, and a somewhat Pythagorean panorama, whose teaching is to love life and do righteousness:

> With ceaseless change how restless atoms pass
> From life to life, a transmigrating mass
> How the same organs, which today compose
> The poisonous henbane, or the fragrant rose,
> May with tomorrow's sun new forms compile,
> Frown in the Hero, in the Beauty smile.
> Whence drew the enlighten'd Sage the moral plan,
> That man should ever be the friend of man;
> Should eye with tenderness all living forms,
> His brother-emmets and his sister-worms.

This poem seems never to have attained the popularity of his earlier work, though more clearly thought through and more sensibly and forcefully written. This may be because it lacked the novelty of the other; either one is more of a stunt, a *tour de force,* than a work of real art. It is, as Dr. Johnson said of a woman's preaching,

[19] "The Temple of Nature," preface. (1803.)

"like a dog standing on his hind legs." When you have seen it once, why try to see it again, though it be more skillfully done now? Furthermore, times had changed. Miss Seward attributes his loss of public favor to the ridicule of his work in "The Loves of the Triangles," but that scarcely seems reasonable. Between 1791, when he published his first poem, and 1803, when his last was issued, great events had intervened. The French Revolution had definitely guillotined the Augustan age with its absurd pretensions and its gracious antiquated modes. A Romantic School of poetry, long on the way, had at last arrived. Its coming was blared forth in 1798 by the "Lyrical Ballads" of Coleridge and Wordsworth. A host of new poets quickly fell into line, and accordingly the posthumous birth of "The Temple of Nature" in 1803 was no more significant a literary event than the publication of a newly discovered poem by Longfellow would be today. Miss Seward's praise now seems absurd, for says she,[20] "He is surely not inferior to Ovid; and if poetic taste is not much degenerated, or shall not hereafter degenerate, the 'Botanic Garden' will live as long as the 'Metamorphoses.'" Even as she wrote, in 1804, Wordsworth was preparing the manifesto of that "degenerated" taste, in his famous "Preface," and the revolution then achieved has proven permanent. A few years later, in a footnote to "English Bards and Scotch Reviewers," Byron [21] declared, "The neglect of 'The Botanic Garden' is some proof of returning taste. The scenery is its sole recommendation."

"The Temple of Nature," though all prepared within, still left the drowsy worshiper nodding outside and had to wait for a fair hearing until sixty years later when Evolution had become a topic to grip men's minds. And then many were astonished and some were charmed to read so

[20] "Life of Dr. Darwin," p. 30.

[21] This is the more remarkable since Byron always regarded himself as of the school of Pope.

complete, thoughtful, daring, and future-piercing, and withal so philosophic—even, making due allowances, so eloquently poetic—a presentation of that remarkable hypothesis: [22]

> . . . Hence without parents by spontaneous birth
> Rise the first specks of animated earth . . .
> . . . Organic life beneath the shoreless waves
> Was born and nurs'd in Ocean's pearly caves;
> First forms minute, unseen by spheric glass,
> Move on the mud or pierce the watery mass;
> These, as successive generations bloom,
> New powers acquire, and larger limbs assume;
> Whence countless groups of vegetation spring,
> And breathing realms of fin, and feet, and wing.
>
> Thus the tall Oak, the giant of the wood,
> Which bears Britannia's Thunders on the flood;
> The Whale, unmeasured monster of the main,
> The lordly Lion, monarch of the plain,
> The Eagle soaring in the realms of air,
> Whose eye undazzled drinks the solar glare,
> Imperious man, who rules the bestial crowd,
> Of language, reason, and reflection proud,
> With brow erect, who scorns this earthly sod,
> And styles himself the image of his God;
> Arose from rudiments of form and sense,
> An embryon point, or microscopic ens!

[22] "The Temple of Nature," Canto I, 295*ff*.

CHAPTER VII

FRENCH AND GERMAN THEORISTS

THERE were others in the old century and at its end, especially on the Continent, who gave expression to more or less clear evolutionary views as to the development of life. Even Werner,* the mineralogist of Saxony who bitterly resisted every advance toward the concept of uniformity, had "noted in successive (geological) formations the gradual approach of extinct forms of life towards existing forms." Not the least of the early Continental evolutionists was the poet Goethe,† whose vast, ready, active, and thoroughly realistic intelligence applied itself among other problems to those of natural knowledge and refused to repeat formulæ, however firmly vested and reputable, unless they approved themselves to it as authentic. His long life is a sort of bridge leading across the whole Romantic period; most of his scientific work was done before Erasmus Darwin had begun to publish, yet when he died Charles Darwin had begun that series of observations which finally raised the idea of evolution from being a lone philosopher's eccentric fancy to its new position as a dominant, all-embracing, and most fertile body of thought.

Now Goethe was not primarily a scientist, but a publicist, novelist, poet, statesman, critic, philosopher, playwright, and courtier as well. Science—his early love—was often crowded from the scene; but for his marvellous endowment of intellect and energy, it would never have reached the respectable scope that it did attain. Furthermore, he was never able to specialize, even within the

* Abraham Gottlob Werner (1750-1817). † (1749-1832.)

scientific field. His writings treat of the physics of light and color, the psychological bases of perception, practical agriculture and forestry, mineralogy and geology, the science of language, archæology, in addition to his more proper areas of botany and osteology. In old age he collected the scattered scientific writings of a lifetime into two volumes totalling nearly twelve hundred pages—a worthy output even for an investigator who had done nothing else, yet, in Goethe's case, forming a strangely pathetic record of frustration. The hasty little sketches, penned in the intervals of other work, the preliminary essays for momentous works that were never written, the linking chapters written later to tell the story of his experiments and observations, all show how great store his heart set upon the knowledge of nature, how little was actually attained in comparison with what might well have been. . . . But this is the tragedy of every aspiring man, and for his sacrifice the poet was richly compensated.

Two of Goethe's scientific works can be definitely spoken of as real successes. Both were impregnated through and through with evolutionary concepts, and each has proven significant and stimulating in its own field. His botanical masterpiece—the "Versuch die Metamorphose der Pflanzen zu Erklären," published in 1790—is a small volume planned to explain the formation and structure of the various organs of plants. It does not even touch upon the question of species formation by means of descent with modification, yet so clearly does his reasoning build upon this idea that Professor Osborn declares that "he anticipated Lamarck as an evolutionist in his 'Metamorphoses of Plants.' "

In this work the development of a plant is studied in reverse order from that in which it occurs, so that we may "learn to know the laws of transformation in accord with which one part brings forth another, and most diverse

forms appear through modification of a single organ." Shortly, then, he studies the growth of an individual plant and concludes that it is made up primitively of stem and leaf and nothing more. Bud and blossom and fruit, together with all their parts, are simply leaves changed somehow to fulfil a special function. He has a very clear understanding of what came later to be known as the *homology* of organs—their relationship through essential unity of descent. All through this work he presupposes an evolutionary teleology, as constant references to the "Ziel der Natur"—Nature's goal—attest. The style of his writing is less overladen than that of many German scholars; it is clear, neat, and sensible, but in no wise poetic nor even entitled to the name of *belles lettres.* It is as if the poet in him were saying, "I must show the doubters that I can be as scientific as anyone."

His "Bildung und Umbilding Organischer Naturen," not published until nearly twenty years later, combines an autobiographical strain with one of biological reasoning more presumptuous and far more philosophical than anything which the author allowed himself in the "Metamorphoses." "If we observe all formed things," he declares, "especially organic ones, we find that nowhere does a permanent or inactive or isolated one occur, but far rather that everything stirs in a constant state of movement." Thus "every living thing is not an individual but a multiplicity," simple creatures being more unified and higher ones showing a subordination of parts. The lowest plants and the lowest animals are scarcely to be told apart.

Becoming reminiscent, he discusses the rather cool reception that his "Metamorphoses" met with, attributing it to the general prejudice in favor of "pre-formation" of all organs in the germ.[22] Here he cites an audacious project of Diderot to evolve goat-footed fauns to serve as

[22] For an explanation of this theory, see Chapter VI above.

lackeys for noble patrons of art. Goethe does not tell whether he considers such radical evolution possible, but he does tell how, thinking that men differed from apes only in a part of the jawbone, he "dedicated [him]self wholly to the study of bone-structures." In both his botanical and his osteological researches, Goethe held strongly to the notion of a primitive or fundamental plan for all the genera of an entire class of life. For all mammalia—possibly for all vertebrates—there is a basic design, or *Urthier,* a generalized animal, which is not exactly reproduced in any single species, but from which every species differs in detail only. The vegetable kingdom, too, must have its primitive plant, or *Urpflanze,* from which, under the influence of climate, "a genus can vary into species, species into varieties, and this again through other circumstances even to infinity." [24]

No doubt more of this was in his mind during the writing of the "Metamorphoses" than the author permitted himself to express. In 1786, five years before that botanical essay, he had told of "a little discovery which [he] believed [himself] to have made," and this in a small book with a formidable title—"To Men Just as to Beasts an Intermaxillary Bone of the Upper Jaw Should Be Ascribed." [25] Earlier osteologists had supposed that man's skull differed from that of the animals in being without this small bone. Goethe, however, found it in the human skull as well, and attributed its faint character to the less angular formation of man's face. Thus, he points out, the elephant, flat-faced like ourselves, has likewise but a vestigial intermaxillary.

Though this essay is a "technical communication" even supplied with a new Latin terminology for the classification of bones, it is composed with vigor and descriptive clearness. The poetry of a vast and meaningful scientific

[24] "Geschichte meines botanische Studiums."

[25] "Dem Menschen wie den Thieren ist ein Zwischenknochen der obern Kinnlade Zuzuschreiben."

idea is fitly expressed. The author shows a real grasp of the comparative method in anatomy. He interprets one form of life by the study of other forms, implying strongly that all are really one substance, moulded in one way here, in another way elsewhere. For instance: "This bone, which is thrust so extraordinarily far forward in the beasts, in man draws itself back into a very little compass." So, too, he proposes a "certain ladderlike comparison of several animals, from the simplest to the most complex, advancing from small and restricted ones to the immense and extended." . . . "What an abyss between the intermaxillary bone of the tortoise and that of the elephant, yet an even row of forms can be set between them that binds the two together."

Among his other essays one meets with other references to the same doctrines, other discoveries tending to the same conclusion. His poetry also shows the effect of this rare knowledge of science, and, unlike Dr. Darwin, Goethe could blend science and philosophy organically with the very substance of his verse, producing not a metrical, rhetorical lecture but a stirring cerebral poem, rich with what Shaw has called our finest adventure, the thrill of exploration in the realms of thought. Few men would have dared to introduce the Walpurgis intermezzo into a drama, as Goethe did in *"Faust,"* where Plutonists and Neptunists, Classicists and Romanticists, and all sorts of political, scientific, and literary partisans debate passionately under cover of the witches' Sabbath. Still fewer would have succeeded. Goethe repeats himself sometimes word for word, but he has a special and peculiar message for the scientist and for the modern man who has learned some portion of what is to be known and who thinks about what he has learned.

One of his later contemporaries, who worked at the same time as Cuvier and Lamarck, is Treviranus,* whom

* Gottfried Reinhold Treviranus (1776-1837).

Huxley cited as one of the founders of the hypothesis of evolution. Treviranus bore a mighty renown in his own day, but is remembered now chiefly as the creator of the *name* of biology. This word was first used by him in 1802 in his work: "Biologie oder Philosophie der Lebenden Natur." Curiously enough, Lamarck also hit upon the same name during that year. The invention represented not only a new name but a new approach; instead of a science of plants—mostly tables of classification—and a separate science of animals, there was henceforth to be a single inclusive science of life, a "study [26] of the different forms and appearances of organic life, of the conditions and laws under which these exist, and of the causes by which they are kept in operation." It was a fruitful concept destined to play a vital part in the development of scientific thought. Treviranus was not marked by great originality in applying his general theory specifically, for much of his teaching was based upon that of earlier writers. However, he is noteworthy for a few definite attitudes: he objected to theorizing not grounded in observation, and also to the mere cataloguing, bare of philosophic coördination, that occupied the followers of Linnæus. He recognized in nature a "law of compensation" keeping the parts of an organism in a state of balance, and he realized the relation of structure and function. He thought, like Buffon and Dr. Darwin, that life arises spontaneously and that the environment can mould it into many forms. "To Treviranus," says *Chambers Encyclopedia*,[27] "organisms appeared almost indefinitely plastic, especially, however, under the direct influence of external forces, nor did he fail to recognize what Brooks, Weismann, and others have recently elaborated, that the union of diverse sexual elements in fertilization was itself a fountain of change." He regarded the "power to adapt its organization to the changes of the outer world" as a

[26] Quoted by Osborn, p. 190. [27] Ed. of 1906.

sort of mystic power within the creature; so naturally he steps through a succession of vaguenesses quite out of the scientific character and turns prophet: "Thus, in Nature, all is in a state of flux and transfer; even man has not reached the highest term of his existence, but will progress to still higher regions, and produce a nobler type of being."

His last great work—"Erscheinungen und Gesetze des Organischen Lebens"—appeared in 1830, by which time evolutionary reasoning had entered upon the last of its untriumphant stages. Oken, a compatriot,[28] contemporary, and colleague of Treviranus, like him published a "Philosophie der Natur" in 1802, in which he outlined his advocacy of spontaneous generation and of transformism. Though a scholar and leading naturalist—M.D. as well as Ph.D.—he was apt to allow more philosophy than nature to creep and intrude and climb into his folios. Many of his ideas strike us as startlingly original and just; but, as often as not, their bases are amusingly unscientific. Thus his idea of the cell as the unit of life—enunciated more than thirty years before cells were first seen by Schleiden and Schwann—has been hailed as a stroke of genius; so that one is a little shocked to discover that Oken supposed cells to be essentially spherical because of some inner necessity toward a mystic sphericity shown also in the shape of the earth, the universe, and the human skull! Haeckel praises him enthusiastically, while Professor Osborn asserts [29] that "his writings are compounds of apparent sense and actual nonsense." Agassiz [30] adds, "He confesses that he wrote the first edition of his work in a kind of inspiration." Be that as it may, he was in his day a courageous and reputable advocate of evolutionary ideas. In his work on "Generation" ("Die Zeugung," 1805) he set forth a sort of cell-theory

[28] Born and educated in Germany, though he taught at Zurich (1776-1851). [29] "Greeks to Darwin," p. 124.
[30] Life of H. Miller in "Footprints of the Creator."

of life, and at the same time as Lamarck, he published an extended discussion of transformism. It is his "Handbook of Natural Philosophy," [31] in which he declares most positively [32] that "no organism, greater than an infusorial speck, has ever been created. No organism is being created, nor has any ever been created which is not microscopic. . . . All larger ones were not created but evolved. . . . Man was not created but evolved."

When one searches for the bases of these most dogmatic denials, one finds beautiful but unproven and often vague declarations. Oken owed much to ancient Greek thinkers, as Anaximander, much to Schelling and the deductive method. . . . His "Handbook" is a compendium of all knowledge, mathematical, physical, chemical, even *God* and *Truth* being arbitrarily defined.

Meanwhile France was becoming the storm centre of the world scientifically as well as politically. The notion of an evolutionary origin of living forms, constantly emerging like the petrel amid thunders and whirlwinds, suddenly appeared in Paris, sponsored by Lamarck, who, declares Professor Osborn, "as the founder of the complete modern theory of Descent, is the most prominent figure between Aristotle and Darwin. . . . His theory was finally taken up by Charles Darwin himself, and . . . it forms the very heart of the system of Herbert Spencer." The old naturalist who chose the rocky path of new ideas might have had a prosperous, adventurous career. His full name, Jean Baptiste Pierre Antoine de Monet,* and his title of Chevalier de Lamarck attest the eminence of his birth. At first he was a brave soldier in the King's army, but, after being injured, he retired from military life and became a physician and then a botanist. He knew Buffon, whose son he accompanied as tutor, and whose latest, very moderate doctrines seem to have been

[31] "Lehrbuch der Natur Philosophie," 1809, third ed., 1843.
[32] *Ibid.*, p. 959. * (1744-1829.)

Lamarck's starting-point. As late as 1794 he published a book [33] in which he denies the transformation of species and the spontaneous generation of life. He was then fifty years of age and distinguished for his work in botany.[34] A fundamental change in his ideas was scarcely to be expected. But meanwhile his master, King Louis had been beheaded, and the Directorate of revolutionary France assigned him to a chair of invertebrate zoölogy in the Jardin des Plantes, at the same time placing Lamarck's greatest adherent, Geoffroy Saint-Hilaire, in charge of the vertebrates. This enlargement of the naturalist's field seems to have given him a broader and more philosophical view of the problems of life and nature. He brought his careful, thorough botanical habits of classification to the study of animal life, saw the analogies between the two kingdoms, and all but revolutionized science and the philosophy that is established upon it. Thus it was he who first classified all animals into the four main branches of *radiates, mollusks, articulates, and vertebrates,*[35] a classification so much more real and significant than any earlier one that it is still the basis of zoölogical study.

It might be supposed that a great classifier would lay great stress upon the permanence of the divisions that he had recognized. Lamarck, however, did no such thing. Perhaps the very difficulty of this work, the doubt that it must often have plunged him into made him humbly conscious of its unreliability. Thus we find him writing: [36] "It was no doubt necessary to break up the productions of Nature into groups, and to establish different

[33] "Recherches sur les causes des principaux faits physiques," written in 1766.

[34] His "Flora Francaise" appeared in 1778 and his "Dictionnaire de Botanique" and "Illustrations de Genres" were contributed to the "Encyclopédie Méthodique" in 1785.

[35] His invention was "Invertebrata." This term was not in use at the time of his appointment, for, he had not then coined it. His department in the Jardin was that of "insecta and vermes of Linnæus."

[36] "Philosophie Zoölogique," Part I, p. 20.

kinds of divisions among them, such as classes, orders, families, and genera. It was, moreover, necessary to fix what are called *species,* and to assign special names to these various sorts of objects. This is required on account of the limitation of our faculties; some such means are necessary for helping us to fix the knowledge which we gain from that prodigious multitude of natural bodies which we can observe in their infinite variety." And again, "Nature has not really formed either classes, orders, families, genera, or constant species, but only individuals who succeed one another and resemble those from whom they spring." And elsewhere,[37] more briefly and sweepingly: "The richer our collections grow, the more proofs do we find that everything is more or less merged into everything else." To appreciate how clear a break with the old and established doctrine of fixity of the forms of life this was, we need only recall what was said sixty years later by Agassiz: [38] "Branches or types are the natural groups of the animal kingdom"; classification and creation form a perfect correspondence, "the former being, so far as it is accurate, the literal interpreter of the latter." . . . "Classification, rightly understood, means simply the creative plan of God as expressed in organic forms."

Thus through his transferring at a mature age from the botanical to the zoölogical domain, Lamarck became obsessed with an affirmative belief in the plasticity of living forms, a belief which dominated his later work. In 1800, six years after the change, he first mentioned evolution in a lecture which was later published as "On the Organization of Living Bodies." [39] It was in this essay that he suggested the term "biology" simultaneously with Treviranus.

[37] *Ibid.,* p. 37.

[38] "Methods of Study in Natural History," pp. 38-42. Agassiz was more conservative than Lamarck.

[39] "Recherches sur l'Organisation des corps Vivants" (1800-1802.)

Soon after he also issued his "Hydrogeology." [40] This work was of less significance in itself and for the geological wisdom it contained, than for the aid its preparation gave him in grasping the development of life. Like Hutton and Playfair, he saw only nonsense in the supposed past catastrophes that most geologists then believed in. He held to the idea of uniformity in natural phenomena, past as well as present; and he realized how much light could be shed upon his own studies by an exploration of the rocks and their fossil population. Geological study gave him an idea of the great length of past time, suggesting also the factor indispensable to any evolution. Thus he wrote: "For Nature, time is nothing. It is never a difficulty; she always has it at her disposal; and it is the means by which she has achieved the greatest as well as the least of her results. For all the evolution of the earth and of living beings, Nature needs but three elements—space, time, and matter."

In his "Organization of Living Bodies" he presents the famous "ladder" or "chain" view of nature, picturing all living forms as joined in a straight line progressively from the lowest to the highest. This view was later replaced by that of a "tree of life" whose particular species, like leaves and twigs, are connected with one another, not directly but indirectly only, through the juncture of the lower branches in the trunk beneath.

During these years, while he was working over the collections at the Jardin, he issued a meteorological annual which appears to have been almost worthless and which was at last quietly stifled by Napoleon's frown. Its fault was due to Lamarck's besetting sin, the tendency to generalization and theory often with too little fact. Of course, these were not wasted years, for during this period he was maturing the ideas and collecting the knowledge that blossomed out in his masterpiece. This book, the

[40] "Hydrogéologie," 1802.

"Zoölogical Philosophy," [41] in method, substance, and literary style sums up Lamarck himself and contains in full the Lamarckian hypothesis for which he is remembered today.

It was intended to be a thorough, well-rounded, philosophical treatise on zoölogy, which in a way it is; yet right from the start and right on to the end, one feels in it the urgency of a missionary appeal advocating a special cause, seeking to win converts. The fanaticism, the enthusiasm, of the belated proselyte vibrates through it, sometimes marring an otherwise limpid style. So, naturally, the author comes to grips with his own special problem early, even before the beginning of the book itself, for in the "Advertissement" there is a sketch of his kind of transformism, typical of the author in views, scientific approach, style, and reflected personality. He writes: "The continued use of any organ leads to its development, strengthens it, and even enlarges it, while permanent disuse of any organ is injurious to its development, causes it to deteriorate, and ultimately disappear if the disuse continues for a long period through successive generations. Hence we may infer that when some change in the environment leads to a change of habit in some race of animals, the organs that are less used die away little by little while those which are more used develop better, and acquire a vigour and size proportional to their use. . . ." [42] The movement of fluids within animals . . . and . . . the influence of the environment . . . were the two general causes which have brought the various animals to the state in which we now see them."

The value of his work among the invertebrates is attested in his "Preliminary Discourse," in which he attacks the custom of studying man, objecting because man's

[41] *"Philosophie Zoölogique,"* 1809.
[42] Hugh Elliot's translation, 1914.

organization is too complex to be clear. We ought, he maintains, to study life first at its simplest terms through an investigation of the lowest forms. Such are the invertebrate species, which are the most numerous, the most widely varied, the most sharply varied, and which show most plainly the order of their development.

As he gets into the current of his work, we come to sense always more and more two personal qualities that mark his style distinctively. One is an insurgent feeling of resentment against the arbitrariness of the standards that he was attacking, the other a tendency to expound theories with the utmost of logical fluency but with a woeful dearth of individual facts. Yet Lamarck must have had a great store of concrete, specific information (as shown in his "Natural History of Animals Without Backbones"). Here, however, he was writing a work not of natural history but of philosophy. Accordingly he covered much, assuming his facts, assuming as it were that his reader also knew all the facts, this book being devoted to inductions and deductions, to general reasonings and conclusions. This weakness led his greatest opponent, Baron Cuvier, to overemphasize the value of facts, to set up a "school of facts," to belittle all of Lamarck's work because of its neglect of this by no means negligible factor. Cuvier's work was the very reverse of Lamarck's—conservative even to excess, heavily documented—just as in personality the two men were temperamental opposites, born enemies. When Lamarck did illustrate his general conclusions, as often as not his example would be one chosen hastily and at random, as if he were impatient at the interruption of his thought, not always appropriate and sometimes incorrect. His work, almost unknown while his fortunate rival was basking in popularity, has survived because, in spite of all weaknesses, his generalizations were fundamentally true

and because they were vital. Cuvier's facts, good as they were, have been absorbed or superseded, his theories have been overturned, and he is slowly being forgotten.

Thus Lamarck did not present to us what he knew but rather *what he thought about the things he knew,* summing up years of research and reflection in a short, pithy chapter. A species, for instance, is called a "collection of like individuals . . . produced by others similar to themselves" but not with "unvarying characteristics." . . . "Doubtless nothing exists but by the will of the Sublime Author" . . . but he could "create *an order of things* which gave existence successively." Thus Lamarck, from a very different approach, agreed with the natural theology of Paley.

He has an almost uncanny power of saying much in few words, of saying it exactly right. Thus, he continues, all animal species "form a branching series, irregularly graded and free from discontinuity, or at least once free from it." How did they change into the great multitude of present forms? Lamarck replies, by the effects of "climate, habits, and manner of life."

This last principle is his contribution to the general theory and comprises what are now known as the "Lamarckian factors" in evolution. Living species thus are supposed to be changed by the direct effect of the climate and by the indirect influence of the environment in its stimulating of changed habits. Animals develop new organs because they need them; a neo-Lamarckian, like Butler, would say, because *they will* to have them. Now this is quite without meaning unless a function or an organ or an improvement acquired by a parent can be transmitted to its offspring. To this day the possibility of such inheritance of acquired characteristics has never been proven. It has often been bitterly denied, often enthusiastically affirmed. In 1926 a brilliant Viennese

biologist [43] shot himself after the collapse of his widely acclaimed demonstration of its possibility. The general attitude of science on this point is affirmatively skeptical. Yet Lamarck simply and calmly assumed it; apparently it never occurred to him that acquired characteristics might perhaps not be inheritable.

Of this, Professor Osborn has written [44] "it is now a question under discussion, whether Lamarck's factor is a factor in Evolution at all! If it proves to be no factor, Lamarck will gradually sink into obscurity as one great figure in the history of opinion. If it prove to be a real factor, he will rise into a more eminent position than he now holds—into a rank not far below Darwin's."

In design, part of his work exactly reverses the order of evolution. He begins, after some preliminary generalizations, with a statement of "the true arrangement and classification of animals," whose aim is "not only to possess a convenient list for consulting, but it is more particularly to have an order in that list which represents as nearly as possible the actual order followed by nature in the production of animals"; the list should "form a series and not a branching net-work." Strangely enough, it begins with man, as the most perfect, and follows the animal chain downward through successive steps of "degradation and simplification" until the simplest are reached. After considering the influence of the environment upon habits and thus upon structures, he presents a new table, this time beginning at the bottom and going up. Here is included a hypothetical history of how apes *might have become* bimanous and thus have grown into human beings.

The second part is an inquiry into the physical basis

[43] Paul Kammerer, author of "Inheritance of Acquired Characteristics."

[44] "Greeks to Darwin," pp. 156-7.

of life, which he holds to be entirely natural:[45] "Beyond nature all is bewilderment and confusion." "Life and organization are thus purely natural phenomena." He believes in the spontaneous generation of the simplest animals and plants—another wholly unproven assumption. The final sections are a treatment of physiological psychology. He considers mental life as quite at one with the physical, declaring [46] "The phenomenon of feeling is not more miraculous than any other phenomenon in nature; that is, any phenomenon produced by physical causes." The "Inner Feeling," the emotions, the will, the understanding, and the imagination are likewise considered.

Such is the principal evolutionary work before Darwin's, a work richly suggestive, fundamentally right, "characterized [47] by a clear and beautiful style, and by a logical development of the argument," characterized, too, by an absurd inadequacy of illustration and fact and a total unconsciousness of the pitfalls which allowed its enemies to nickname each new Lamarckian book a *"nouvelle folie."*

The old age of the author was very pathetic. Too poor to buy proper instruments, yet driven by the devil of research to ever increased effort, he lost his eyesight in 1819. Yet he continued at work, dictating to his daughter the last two volumes of his "Natural History of Animals without Backbones." [48] His sacrifice and hers met with no recompense, for his books were not widely read nor were his ideas respectfully received, save by a few chosen men, born ahead of their time, like the ever-faithful Geoffroy Saint-Hilaire. Thus to the world he was just another of the innumerable philosophers who have devised quaint systems, neither more nor less. His

[45] *Philosophie Zoölogique,* p. 212.
[46] *Ibid.,* p. 330.
[47] Osborn, p. 161.
[48] "Histoire Naturelle des Animaux sans Vertebres," 1822.

zealous advocacy met with complete contemporary failure. He died in 1829; a year later Saint-Hilaire, defending transformism in a series of debates at the Academy of Sciences in Paris, had to confront the superior skill, address, and personal popularity of Cuvier, and the cause of fixity was established beyond a doubt and for all time!

CHAPTER VIII

A FEW ECCENTRICS—THE GREAT DISCUSSION AGAIN

Now the tale tells of a London physician, a native of South Carolina, who had returned to his father's country in protest against the American Revolution. Dr. Wells * was a brave and capable man, skilful in the art of healing, and born with a certain fluent vitality in his pen almost enough to establish him as a genius in simple expository writing. Also he was naturally curious as to all sorts of physical and natural occurrences going on about him; he loved to experiment even upon his own body, and he reported his findings to the Royal Society, of which he was a Fellow, in characteristically vivid and delightful prose. It was he who first expounded our power of single vision with two eyes,[1] and he wrote other excellent articles as well upon vision, and color, and the dew, upon the then new and startling muscular effects of electricity, and upon the color of the blood. Yet he would not be remembered at all today—even by the few students of scientific history who do remember him—had he not come by accident into contact with the strange case of Hannah West.

This unfortunate woman, though of unquestioned Anglo-Saxon descent and appearance, had a large patch of black skin covering an arm and shoulder. Dr. Wells

* (1757-1817.)

[1] "Two Essays: one Upon Single Vision with Two Eyes; the Other on Dew (1814) A letter to the Right Hon. Lloyd, Lord Kenyon, and an Account of a Female of the White Race of Mankind, Part of Whose Skin Resembles that of a Negro; with Some Observations on the Causes of the Differences in Colour and Form between the White and Negro Races of Men," 1819.

examined her and found her to be an entirely normal English working-woman, not diseased nor different from others except in this sole way. Through some inexplicable cause, she simply had *mutated* in the direction of the Negroid.

Dr. Wells reported his observations upon her case and his deductions therefrom in a paper that was read before the Royal Society in 1813. Of this paper Darwin says,[2] "he distinctly recognizes the principle of natural selection, and this is the first recognition which has been." Upon Darwin's single sentence, Wells' immortality depends.

It should not be so. His work is sound enough, both as science and as literature, to live upon its own merit. As in his other reports, Dr. Wells chooses the attractive narrative form: he tells what he did, what he observed, how he was impressed, and what conclusions he reached and by what stages. It is a short detective or "mystery" story that he gives, vivid with details as to the black arm and shoulder, its color, smell, touch, structure, its response to the medical scissors, and so on. His conclusions are speculative but well-reasoned, philosophical, original, and far-seeing. Negroes, he holds, are not a distinct species, nor is their color due to the direct influence of the sun's light or heat. Instead he explains it by "a view . . . which has not been given by any author whose works have fallen into my hands," adding, "I shall therefore venture to mention it here, though at the hazard of being thought fanciful rather than just." Now we know that the climate of Africa is dangerous to Europeans, as that of Europe is to Africans. Hence a colony in the wrong land would "become incapable of supporting life by their labour. In the meantime their children would die from want, or disease induced by deficient or improper nourishment, and, in this way, a colony of the negro race in a cold

[2] Hist. Introd. to "Origin of Species."

country would quickly cease to exist." Color itself is "only a sign of some difference in them." "Varieties of a greater or less magnitude are constantly occurring," and in small tribes "an accidental difference . . . will often descend to their late posterity." Here he anticipates a greater theorist by citing the use and effects of selection—the artificial sort—in "the improvement of domestic animals" and proceeds to natural selection thus, "But what is here done by art, seems to be done, with equal efficacy, though more slowly, by nature, in the formation of varieties of mankind, fitted for the country which they inhabit. Of the accidental varieties . . . some would be better fitted than the others to bear the diseases of the country." This race would consequently multiply "while the others would decrease; not only from their inability to sustain the attacks of disease, but from their incapacity of contending with their more vigorous neighbours. The colour of this vigorous race, I take for granted, from what has already been said, would be dark. But the same disposition to form varieties still existing, a darker and darker race would in the course of time occur; and as the darkest would be the best fitted for the climate, this would at length become the most prevalent if not the only race." So far, Wells has applied the idea of natural selection only to the races of mankind; in conclusion he extends the principle to include other living species, for instance, the Spanish sheep naturalized in Sweden.

The entire essay is only fourteen pages long. It is but one casual part of the work of a man whose total collected writings, including an autobiography, fill a single scant volume. It is admittedly conjectural, yet it strikes nearer the accepted hypothesis of evolution than do the magnificent evasions of Buffon, the no less pretentious assertions of Dr. Darwin, or the belligerent postulates of Lamarck. There is in it a minimum of metaphysical or esoteric reasoning. Beginning with a single careful ob-

servation and with some general knowledge such as is altogether common among men, reasoning simply and sensibly, Wells comes to very sound conclusions, and he states them in an admirably readable form.

With the name of Wells is usually associated that of one Patrick Matthew, probably because in the historical sketch prefaced to the later editions of "The Origin of Species," Darwin cited these two men as actual forerunners of his in recognizing the principle of natural selection. Matthew's statement of the transformist theory is a brief one occurring in an appendix to his book "On Naval Timber and Arboriculture." * He is less significant than Wells not only in having written later, but also because he fills out his theory with certain rather obscure metaphysical excrescences. "He clearly [3] saw, however, the full force of the principle of Natural Selection." In "Emigration Fields"—a study of the various countries to which England might send her excess population, New Zealand being pointed to as the most promising—Matthew seems constantly to imply, though he does not state, the ideas of adaptation to environment, struggle for existence, natural selection of the fittest, and modification of species.

One year before the appearance of Matthew's book, Cuvier and Saint-Hilaire† had faced each other before the Academy of Sciences in Paris and debated the question of fixity or transformability of species. Cuvier, who was a baron and had a knack of winning influential friends, favored the established side and carried it to a success that persisted in England as well as in France until 1859.

Yet in his earlier work he had sometimes written almost like an evolutionist. His [4] most popular work is called a "Discourse on the Revolutions of the Surface of the

* (1831.) [3] Preface to "Origin."

† Etienne Geoffroy Saint-Hilaire (1772-1844) and Baron Georges Cuvier (1767-1832.)

[4] "Discours sur les Revolutions de la Surface du Globe et les Changemens qu'elles ont produit dans le régne animal," 1807 (?) trans. by Jamieson as "Essay on the Theory of the Earth," 1817.

Globe and on the changes which they have produced in the animal kingdom." In this essay he declares that "there has been a succession of variations in the economy of organized nature, which has been occasioned by those of the fluid in which the animals lived, or which has at least corresponded with them, and these variations have gradually conducted the classes of aquatic animals to their present state." Yet he thought of the changes of the earth as catastrophes —*"revolutions"* to use his own word—and therefore it was impossible for Cuvier to see the value or possibility of any system to which slow growth was essential. "Most of these catastrophes," he writes,[5] "have been sudden. Life therefore has often been disturbed on this earth by terrible events." Certainly and emphatically, he was no uniformitarian, holding, as he did,[6] that "it is in vain that we search, among the powers which now act at the surface of the earth, for causes sufficient to produce the revolutions and catastrophes, the traces of which are exhibited by its crust."

In one respect at least, though not altogether willingly, one suspects, Cuvier lent ammunition to his scientific enemy. He was one of the leading palæontologists of the day; his numerous discoveries and classifications of fossil extinct species, taken together with the similar work of William Smith and with John Hunter's studies in comparative anatomy, supplied much of that stock of knowledge as to kindred forms of life from which later evolutionists were to draw significant conclusions. He published works on "The Species of Elephants Living and Fossil," [7] on the *siren lacertina,* a prehistoric link between the great extinct reptiles and the living crocodiles, on mollusks [8] and fishes [9] and quadrupeds.[10] He was the

[5] *Ibid.,* p. 14.
[6] *Ibid.,* p. 35.
[7] "Mémoires sur les Especes d'Éléphants vivants et fossiles," 1800.
[8] "Mémoires pour servir à l'Histoire et à l'natomie des Mollusques," 1817.
[9] "Histoire naturelle des Poissons," 1828-31.
[10] "Recherches sur les Ossemens fossiles de quadrupèdes," 1812.

first to demonstrate the actual reconstruction of an extinct animal, and he made some notable advances in classification over the more primitive system of Linnæus.

His career was crowned with the most impressive success. Napoleon and the Bourbons alike delighted to honor him; he was made a peer of France and held more than a few political posts of importance, while "the scientific honors which he received are beyond enumeration." [11] As professor of natural history in the College de France, titular professor in the Jardin des Plantes, perpetual secretary of the National Institute, he wielded tremendous influence. Sad to relate, he used this power as well as the force of his learning and his literary dexterity to throttle the new theories of Lamarck and Saint-Hilaire. As time went on he became more and more of an anti-transformist, ridiculing successively every *nouvelle folie* of his theorist opponents. His stand was taken firmly upon facts, of which he was an acknowledged master, and in determined opposition to everything hypothetical. Professor Osborn points out, however, that for all his great knowledge of facts, Cuvier was quite unreliable when he tried to combine facts into any more general body of thought. From a theory of "a succession of special creations" he gradually withdrew to a more conservative position. We have already remarked on his failure to recognize the principles of uniformity; he missed even more remarkably the inevitable evolutionary conclusion of his own discoveries.

A curious testimony not only of the positive character of Cuvier's later anti-evolutionary views but also of the fair power that transformism had been attaining and might have held but for him is given in an English review of one of his books.[12] "Cuvier," says the applauding re-

[11] "Encyc. Brit.," 9th ed.

[12] "Le Régne Animal," English translation, "The Animal Kingdom arranged in conformity with its organization"; reviewed in Athenæum, Aug. 28, 1830.

viewer, "was the first that assigned to man a proper place in the scale of animals—took him out of the society of the ape and the bat, to which he had been condemned by Linnæus, whose arrangement of animals being wholly by the teeth, necessarily groups together those which had few other qualities in common." This work, "The Animal Kingdom," was one of the more comprehensive and popular of the writings of Cuvier. When engaged upon any work likely to be widely read, the baron wielded his pen like a gentleman and scholar. In respect of literary style, if in nothing besides, he is of the school of Buffon. The translator of his "Discourse on the Revolutions of the Surface of the Globe" calls it an "elegant essay"; no term more fitting could have been chosen to describe it, either in that bygone era when "elegant" was an epithet of highest praise or at present when it, like the quality it represents, is fair game for the sneers of the illuminati.

Strangely enough, it was through the influence of Saint-Hilaire that Cuvier first made his way into the scientific world, and the two predestined opponents collaborated in the writing of five memoirs.[13] One of these joint papers contains the idea of "the subordination of characters," upon which Cuvier's system lays much emphasis, and one expounds Saint-Hilaire's pet concept of "the unity of organic composition." It was from this idea of unity that Saint-Hilaire advanced into transformism. Teaching him to seek a single underlying plan beneath the diversities of animal form, it led him to the notion of an "archetype," or primitive creature, a sort of universal animal ancestor, an Adam of the whole living world such as Goethe had conceived under the name of *"Urthier."* His special studies in teratology, the science of abnormalities and monsters, showed that not all beings are born to

[13] Saint-Hilaire's son states that for a time they shared everything together, and "That they remained personal friends even when they had become scientific enemies."

reiterate the bodies and the lives of their parents. Some burst unaccountably out of the mould of the species; yet not quite unaccountably either, for, says Saint-Hilaire,[14] "monsters are not sports of nature; their organization is subjected to rigorously determined rules and laws; and these rules, these laws are identical with those that rule the animal series; in a word, monsters are also normal beings; or rather there are no monsters, and Nature is one." Why, then, may not new forms become the progenitors of new species? Why may not the species we know have descended from the archetype by changes sudden or gradual? In supposing that some of the changes might be abrupt, he differed from Lamarck, who held that individual variations were slight and the complete process a very long one. He even, in one ambiguous passage, suggested what later became Darwin's basic doctrine: that modifications which aid their possessor to survive in the struggle for existence tend to become fixed. He explained the emergence of new variations as a direct response to the action of the atmosphere upon living bodies.

Saint-Hilaire was learned, but, unlike Cuvier, he was no peripatetic encyclopedia of facts. He could not worship a fact for its own sake. Some congenital tendency turned him toward connecting separate facts and organizing them into systems of theory. It is characteristic that his greatest work is called an "Anatomical Philosophy." [15] He was definitely a philosopher—a title which Faraday preferred to that of *scientist*—and owed not a little of his thought to the doctrines of Schelling. Yet, according to Dr. Osborn, he "sought to revive speculation and place it upon the true inductive-deductive basis." His son, Isidore Geoffroy Saint-Hilaire, points out [16] the

[14] The words are his son's. *Ibid.*, p. 260. (See below, Note 16.)

[15] "Philosophie Anatomique," 1818-1822.

[16] "Vie, travaux, et doctrine scientifique d'Etienne Geoffroy Saint-Hilaire, par son fils," 1847, p. 206*ff*.

great value of the method which should immortalize its inventor even if his conclusions should prove to be incorrect. In his method he went far beyond his famous rival; for him "to [17] observe, to describe, to classify was not the whole of science but the beginning of science." He recognized in himself a [18] "need of unity, . . . an invincible tendency toward synthesis which inspired him and well-nigh overwhelmed him." Thus he succeeded in formulating a set of inductive principles, in whose light his facts were grouped, by means of which his observations were inspirited with vital significance.

The chief factor in his method was called the "theory of analogies." Assuming a certain analogy between corresponding parts of the skeletons of different vertebrates, Saint-Hilaire often discovered the relations of puzzling structures. Associated with this were a "principle of connexions" and a principle of compensation, called by him the "balance of organs." He reached this through a study of rudimentary organs, which convinced him that there is a certain balance among the parts of a body; if one part grows (by evolution) some other part must waste away. Above all, he held to a "general idea of the unity of organic composition." This means that all vertebrate animals—perhaps all animals of all kinds—are built in accord with a single fundamental plan. This general idea was not new with him; we have met it in Goethe, Oken, and others; but Saint-Hilaire, by virtue of industry, personal force, and sheer power of thought, developed it and made it peculiarly his own. By an application of these principles to painstaking research he discovered, for example, a system of teeth in birds and of ear-bones in fish. At these conclusions Cuvier was shocked; "It is impossible," he said, but he was candid enough to retract when the proofs were shown and to praise the system of Saint-

[17] *Ibid.*

[18] *"Études progressives,"* 1835. See also *Vie, travaux,* etc., pp. 400-1.

Hilaire publicly. That was in 1821. By 1827 the two naturalists, still friends, had drifted so far apart that they were attacking one another's doctrines.

On February 15, 1830, Saint-Hilaire reported before the (French) Royal Academy of Sciences on the recent work of two young naturalists. Incidentally he referred to his own favorite doctrine of the "unity of organic composition." At the session of a week later Cuvier replied with a strenuous attack upon this idea. Geoffroy replied extempore, and a debate was launched that lasted over several months and attracted wide notice. When either of these Titans was to speak, the visitors' seats were sure to be overcrowded and the grave academic hush was replaced by tense and eager excitement. Saint-Hilaire had the last word, for a time came when Cuvier thought it no longer dignified to reply—except in his later writings. His opponent then did the same, hastily producing his "Principles of Zoölogical Philosophy," [19] and other works planned for public reading.

To recognize the winner of this war of words is not easy. Saint-Hilaire's partisans [20] argue that he won, or at any rate should have done so, for Cuvier had withdrawn from the discussion. Furthermore the public applauded Saint-Hilaire, and two contemporary newspapers wrote favorably of him. The biographies of Cuvier are singularly silent, ominously silent, about the entire discussion. Nevertheless, histories of biology generally treat this affair as an unfortunate set-back for the theory of evolution and thus for the progress of science. There is no doubt that general scientific thought for almost three decades thereafter—and with only one noticeable flurry—moved steadily along non-evolutionary lines. This was

[19] "Principes de Philosophie Zoölogique," 1830.

[20] See "Vie, travaux, et doctrine," p. 384; also Goethe, "Principes de Philosophie Zoölogique Discutés en Mars 1830 au sein de l'academie royale des sciences par M. Geoffroy de Saint-Hilaire." (Goethe's Werke, vol. 8, pp. 167-214.)

largely due to the immense prestige of Baron Cuvier. Indeed Cuvier's influence is mentioned by Andrew D. White in his "Warfare of Science with Theology" as the greatest obstacle that evolutionary thought had to contend with during the first half of the nineteenth century.

Both contestants continued the discussion vigorously in their writings. Cuvier's last lecture in the College de France was an attack upon the "unity of organic composition"; so was his last, unfinished manuscript, from which his writing hand dropped in 1832. Geoffroy was his scientific enemy and personal friend to the last; he pronounced a beautiful elegy over his fallen rival, naming the latter—as he had himself predicted when inviting Cuvier to Paris—"the first naturalist of our days."

Geoffroy was an uneven and not altogether skilful writer. Full of fire and the breath of prophetic oratory when aroused, as in his "Preliminary Discourse," he becomes fagged and even tedious at times. His excellent eye for anatomical details is far more evident from his plates than from any of his descriptive writing. He is at his best and seems most at home in argumentation about theories that were unprovable but searching and vital. The power of his personality can be sensed in his books. Yet he had not—nor had any of the men we have been considering—that peculiar blend of scientific dependability and unaffected literary richness which made Darwin's work a force in the world. Perhaps that is one reason why none of the others really succeeded in bringing evolution affirmatively into the real world.

CHAPTER IX

"VESTIGES OF CREATION" AND "FOOTPRINTS OF THE CREATOR"

In his old age, Saint-Hilaire saw the ideas of Cuvier triumphantly and maliciously contrasted with his own. When he died in 1844 the only evolutionary eddy between 1830 and 1858 was stirring the turbid waters of biological discussion. It came from Edinburgh, in the form of a small volume, closely printed and crowded with stimulating suggestions. This book, usually known as the "Vestiges of Creation," * was issued anonymously. This caution was wisely taken, for the book became the storm-centre of a literary, political, religious, and popular excitement quite beyond anything hitherto recorded upon evolutionary questions. Men of science were annoyed by its obvious lack of affirmative, first-hand knowledge of nature, its slipshod delight in theorizing. Huxley abused it, and Darwin thought it feeble and childish. But the lay world was arrested and shocked into attention by the daring and ingenuity of the theories which it set forth. It hurled a new, more brutal but more thrilling concept of nature into some of the poetry of the period in place of the solemn or pretty—but not always convincing—view held by the late Romanticists. Tennyson, for instance, soon began to envisage "Nature red of tooth and claw," and to ask:

> "So careful of the type?" but no.
> From scarped cliff and quarried stone
> She cries, "A thousand types are gone:
> I care for nothing, all shall go."

* "Vestiges of the Natural History of Creation" (1844).

Man is advised to

> Move upward, working out the beast,
> And let the ape and tiger die.

The poet had himself been

> Nourishing a youth sublime
> With the fairy tales of science and the long result of time.

and these forces were felt in his writings. All of the above quotations, taken from poems written before 1850, show unmistakably the influence of ideas of evolution. Long afterward he declared [1] that the ideas of evolution "must have been in the air at the time." If they were "in the air," it was by way of the "Vestiges" that they had been broadcast. Since the time of the old Bestiaries or at least since the "Foure Footed Beestes" of Edward Topsell, there had been no such inundation of "fairy tales of science" as were here presented. The anonymous author of the "Vestiges" was a mere dilettante in actual science, drawing his ideas from Lamarck, Laplace, Paley, the Bridgewater treatises, Nichol,[2] Prichard,[3] and his own fertile though logical imagination. Yet he was an enthusiast, full of his subject—at least for the moment—and eager to convert as many as possible to his philosophy.

Who wrote this book? Considering the animosity aroused by its heretical doctrines, the author was well advised in concealing his name. Yet suspicion soon fell on Robert Chambers,* an Edinburgh publisher, who at all events did not deny his authorship. In 1848 he confessed himself the author of a work on "Ancient Sea Margins," similar to the "Vestiges" in both style and message,

[1] See Edw. B. Poulton, "Charles Darwin and the Origin of Species," 1909.

[2] Nichol, "Views of the Architecture of the Heavens," 1837, mentioned in the "Vestiges" and praised for great "clearness of thought and elegant and impressive language."

[3] Prichard, "Natural History of Man."

* (1802-1871.)

though far less outspoken. In the same year, we are told,[4] Chambers "would have been made Lord Provost of Edinburgh if rancorous feeling had not been stirred against the supposed author of a work inconsistent with a literal faith in the Book of Genesis." Upon his death—forty years after the "Vestiges" appeared—acknowledgment that he had written it was made.

The publishing house of W. & R. Chambers was doing in the Scotch city what Charles Knight, Lord Brougham, and the Society for the Diffusion of Useful Knowledge had long since begun in London. An avid thirst for learning—theological or scientific or both—marked a large, active class of the Scotch people. Philosophy had flourished among them for generations. Some of the best of the early geologists were of that nation. This interest, further, represented no intellectual aristocracy, but moved many men of the laboring and shop-keeping classes. For men such as these, then, Chambers wrote a book that, while not exactly dependable as an authority on natural history, is astonishingly rich in real knowledge, in ideas, so vividly expressed that it "set[5] many talking and some thinking, and was one of the first signs of a new rise in the tide of scientific thought." Naturally it went beyond the lowly public it had been planned for; for instance, Fitzgerald writes,[6] "I found people talking about it here; and one laudatory critique in the *Examiner* sold an edition in a few days. I long to finish it." Just as in our own day educational books with a popular flavor are best sellers, the "Vestiges" in the '40's swept the field. And professional scientists were as displeased with it as professional philosophers are now with "The Story of Philosophy."

Chambers did not aim to attack religion. "He[7] did

[4] H. Morley, "Eng. Lit." [5] See Morley.
[6] Letter to B. Barton, Jan. 4, 1845. (Macmillan, "Letters of Fitzgerald," 1894.)
[7] Preface to 10th edition.

not do so . . . in an irreverent spirit, or with hostile designs to any form of faith or code of morals. He viewed the inquiry as simply philosophical." Though a believer at least in "natural theology," he "was not long in perceiving that the commencement of life and organization was very unsatisfactorily accounted for by 'fiats,' 'special miracles,' 'interferences,' and other suggestions and figures of speech in vogue among geologists." He was aware of the weaknesses in Lamarck's theory and, being unacquainted with Saint-Hilaire's, claimed originality. "After long cogitation, the idea at length came unpromptedly into his mind—and therefore so far an original idea—that the ordinary phenomenon of reproduction was the key to the genesis of species. In that process . . . we see a gradual evolution of high from low, of complicated from simple, of special from general, all in unvarying order, and therefore all natural, although all of divine ordination."

The author's own account of his book is exemplary in its fairness. Naturally, however, he told only of the one part of his book which aroused most discussion, though there is much more to the volume. It is actually a compact little "outline of science"; its very title shows his purpose to make a complete "natural history of creation"—"as far as I am aware . . . the[8] first attempt to connect the natural sciences into a history of creation. The idea is a bold one. . . . My sincere desire . . . was to give the true view of the history of nature, with as little disturbance as possible to existing beliefs, whether philosophical or religious." Therefore the book begins with an astronomical section, an account of "the Bodies of Space, their Arrangements and Formation." Under this heading there is an exposition of the "nebular cosmogony of Herschel and Laplace," whereof the author once more specifies that "the[9] work may be said to have

[8] "Vestiges," p. 188. [9] *Ibid.*, p. 11.

been done by the will of God, expressed in the form of the law of gravitation."

From astronomy he proceeds to physics and chemistry in a brief section on "Constituent Materials of the Earth." Geology, Chambers' most familiar science, is best represented. It is here that the evolution of living forms is first hinted at in his mention of "the Stone Book," which "might [10] be described as a record of the state of life upon our planet from an early to a comparatively recent date." Carefully he traces the successive appearance of higher and higher forms in more recent strata.

The account of the Permian era is introduced by an elaborate picture of life in that bygone age, an imaginative description that is worthy of quotation entire: [11] "Day after day, through long-drawn ages, the sun passed on his course. Night after night, the sparkling garniture of the sky looked down on this green world. But a being of superhuman intelligence, coming to examine our globe, would have seen all this existing only for fishes and still humbler creatures in the sea, and for reptiles, insects, and perhaps a few birds, and still fewer opossums upon land. He would have beheld the tyrant sauria pursuing their carnivorous instincts upon the wave, upon the shore, and even in the air; huge turtles creeping along the muddy coasts; still more huge megalosaurs traversing the plain; and with all this, the air filled with multitudes of insects. But no flocks would have met his eye upon the mountains, no herds quietly roaming in the valleys. . . . What a vast void! And yet the certainty that in good time, in the ripeness of the plans of the mighty Author, the higher animals were to come, and among the last the Creature of Creatures—Man."

Something of the original thrill, the old dignity can still be felt even in this age of lean, spare, athletically

[10] "Vestiges," p. 31. [11] *Ibid.*, p. 89.

stripped rhetoric. Certainly Chambers could write. Here was no musty pedant, no fanatical researcher impatient of words and sentiments, but a born orator, an artist in phrases, pompous, perhaps, but gifted with a clear mind, a vivid imagination, and a ruling passion to present his knowledge in such form that readers could understand it—as we often say, could *see* it—and could feel the living power within it. It is no wonder that,[18] as he later declared, "the fate of the book was not to rest in obscurity or oblivion, but to be extensively read, and become the subject of much animadversion. It has never had a single declared adherent—and nine editions have been sold. Obloquy has been poured upon the nameless author from a score of sources—and his leading idea, in a subdued form, finds its way into books of science, and gives a direction to research."

But to return: his leading idea does not even yet emerge, for the later geological adventures of the earth must still be given. Chambers shows wide reading, taking in Cuvier's study of extinct pachydermata, Lyell's division of the tertiary age into eocene, miocene, and pliocene, and even the "curious enquiries of Mr. Darwin" into the formation of chalk. He presents a combined diluvial and glacial theory, supposing[18] "a quantity of loose blocks hurried over them by a flood, possibly one in which there were large rafts of ice." With the same forward-looking instinct he discards catastrophism as a doctrine that is "now passing away."

It is only in Part II—"General Considerations Respecting the Origin of the Animated Tribes"—that Chambers reminds us of "the whole region of the inorganic" being "taken out of the dominion of marvel" and asks, "Can we touch at, and rest for a moment on, the possibility of plants and animals having likewise been produced in a natural way . . . ?" And this natural way requires time

[18] Preface to 10th edition. [18] "Vestiges," p. 105.

as the first essential of organic progress, time for life to alter, leaving its record in the rocks. Clearly the greater similarity of recent (as compared with ancient) fossils to existing animals is a proof of actual kinship. Life, thinks Chambers, came spontaneously into being on earth and on other planets also. It has a physical and chemical basis and can be moulded and changed by the influence of physical and chemical forces. Indeed he suggested that lightning may have given trees their shapes! Recapitulation traces for us, in the prenatal life of every individual, the prehistoric life of the race, showing its growth from a single cell, not wholly independent, to a multiplex creature with many specialized organs.

In his "Hypothesis of the Development of the Vegetable and Animal Kingdoms," Chambers shows a good conception of the *homology,* or structural parallelism, of corresponding organs in various species. Says he,[14] "The giraffe has in his tall neck the same number of bones with the pig, which scarcely appears to have a neck at all." Briefly and logically, with but slight recourse to facts, the actual hypothesis is outlined. Here are snatches from Chambers' own summary: [15] "The whole train of animated beings, from the simplest and oldest to the highest and most recent, are, then, to be regarded as a series of *advances of the principles of development,* which have depended upon external physical circumstances, to which the resulting animals are appropriate. I contemplate the whole phenomena as having been in the first place arranged in the counsels of Divine Wisdom, to take place not only upon this sphere, but upon all others in space, under necessary modifications. . . ." He resumes, "The production of new forms . . . has never been anything more than a new stage in the progress of gestation, an event as simply natural, and attended as little by any circumstances of a wonderful or startling kind, as the

[14] *Ibid.,* p. 95 (edition of 1858). [15] *Ibid.,* p. 99.

silent advance of an ordinary mother from one week to another of her pregnancy."

Thus we see that Chambers had a far-reaching conception of the growth of life, a view splendidly unified, simplified, and extended, based on reality and shaped by a philosophical mode of thinking. But, except for "external physical circumstances," he had supplied no motive power, no guiding, directing force, save "the counsels of Divine Wisdom, . . . the immediate favor of creative will or energy." He sneered at Lamarck's idea that animals might form themselves by unconsciously willing to have organs such as would meet their needs, a theory, said he, which "deservedly incurred much ridicule although it contained a glimmer of the truth. We can only place it with pity among the follies of the wise."

His own theory considered evolution as predestined and following of necessity a certain course. The World, that universal Mother, has given birth to a single child which includes all life; that child goes through certain typical stages of infancy, youth, maturity, and age, as a matter of course; life is first one-celled, then vermiform, crustacean, piscine, reptilian, and later bird, marsupial, and mammal, reaching maturity when it becomes man. If one thinks that kinship—that past identity—with the beast is degrading, Chambers utters a reminder that thinking of "the circumstances attending the production of an individual of our race, we might equally think them degrading and be as eager to deny them. . . . Such notions are the emanations of false pride and ignorant prejudice."

The few concluding sections are given over to a short anthropological history. Much of what Chambers has to say here was deduced from a study of language. He is consistent in applying the evolutionary explanation to man as well as to other creatures, and to man after as well as before he became man. A consideration of actu-

arial statistics convinces him that all are "under the presidency of law." Evil is due to the (exceptional) conflict of laws that in themselves are good. The author of the "Vestiges" is certainly a teleologist. He is sure[16] that "we may regard the globes of space as theatres designed for the residence of animated sentient beings, placed there with this as their first and most obvious purpose; namely, to be sensible of enjoyments from the exercise of their faculties in relation to external things."

To us of the twentieth century, the "Vestiges" would seem to be, for a work of science, quite unnecessarily over-religious. Theology is laid on with a trowel thickly enough to make one suspect the author's sincerity. However we happen to know Chambers' record, which is enough to show that he was a genuinely and earnestly religious man. The secrecy in which he kept his authorship, taken together with reports of how the book was received, prove amply that it did not seem a pious work at the time but quite the contrary. In 1844 the "Vestiges" was an extreme expression of radical infidelity.

It did not win either the scientific or the lay world over to a belief in evolution. It could not. Chambers, like Lamarck and Wells and Saint-Hilaire, did not know enough to prove his point. Besides, the public mind was not prepared to receive this particular idea. What the "Vestiges" did accomplish was to prepare the public mind to receive it, so that when a greater scientist, better writer, and wiser man came forward in the same cause, he found the rock more ready to split because of the blows of his unsuccessful fore-runner. Chambers' work aided in a more direct way also, for there was one great scientist, a man of deeply religious nature, who in his youth was roused and stirred and mentally directed by the "Vestiges"; that man was Alfred Russel Wallace, co-discoverer with Darwin of the theory of natural selection.

[16] *"Vestiges,"* p. 184.

Chambers did not stop writing. For forty years his fluent pen welled with material for the busy presses of his publishing house and for the eager eyes of his wide circle of readers. Sometimes he again touched a scientific theme, more often a religious one or one concerned with tradition and curious lore, occasionally a blending of these. Reference has been made to his "Ancient Sea Margins." A few years later the "Explanations" appeared, anonymously like the "Vestiges," which it sought to explain. This vividly written book is the author's response to criticisms of his more independent work, whose method it repeats. Like the former, it takes the shape of a short synopsis of all science. It resembles the "Vestiges," too, in its brilliant argumentation for a natural view of natural history, in the clarity of its visual images. It is more emphatic; the author, worried by his persecutors, is at bay and fights back viciously. The book is wholly secondary and therefore, in spite of good, vital art and a display of spirit, has far less permanent interest than his other. There is just one new and important thought which it expresses: that evolution is not a theory of the origin of life but a mode of working in its development, the concept of law rather than something more arbitrary in the forms of life. The author is well known also for his "Book of Days," a great but heterogeneous assemblage of traditionary learning. It is a source-book for anthropological study, in which the author's closeness to, and interest in, the plain people of the Scottish wilds lent him an understanding sympathy. "Chambers Encyclopedia" remains a monument to his editorial greatness.

One of his opponents was a man in some ways strangely like himself. Hugh Miller,* like Chambers, was Scotch and lived for a time in Edinburgh. He also was a man of humble origin who never outgrew his contact with the common folk of border and highlands. Furthermore Mil-

* (1802-1856.)

ler was a religious man, a theological philosopher like Chambers, but more—a personality rich with that earnest, emotional conviction which is called faith. Above all, he was a far more gifted artist than even the excellent Chambers. He was one of the very finest literary masters who have ever undertaken to write on scientific subjects. "Literature," he declares, "and, mayhap natural science, were, after all, my proper vocation."

His life was an unusual one compact of plain living and high thinking. One would call it a happy life save that he died by his own hand. Son of a sailor, grandson of a buccaneer, he passed his adventurous boyhood in Cromarty where a wild sea never rests from its onslaughts against the rocks of the Scottish coast. It was in this place close to the works of nature that without teaching he laid the foundations of great geological learning. At about fourteen he began to work in a quarry. The very first morning's work led him to ask, and in part to answer, questions that loom high in geological science. As a stone mason, he was out of work during a large part of every year; he chose that trade because it would leave him time which "should be given to careful observation, and the study of our best English authors." [17]

The story of his early experience is told in a fascinating autobiography, "My Schools and Schoolmasters" (1854). The first of these . . . [18] a "tract of sea-bottom laid dry by the ebb formed an admirable school, and Uncle Sandy an excellent teacher. . . . There are professors of Natural History that know less of living nature than was known by Uncle Sandy." When he reached Edinburgh, attracted by the high wages, he went to every church of importance and noted the doctrines and styles of the preachers. Later he played a manly part in the Great Disruption [19] and in 1840 became editor of *The*

[17] "My Schools," p. 151. [18] *Ibid.*, pp. 63, 62.

[19] For Miller's writings in this field, see "The Cruise of the Betsey" and "The Headship of Christ."

Witness, a sectarian organ that favored non-intrusion. For this journal he wrote his first considerable scientific essays.

Even as a boy he had loved poetry. He often quotes Wordsworth in his writings, exemplifies Wordsworth in his way of living. He had early published a volume of "Poems Written in the Leisure Hours of a Journeyman Mason," [20] which are pretty and regular and which speak well of nature. In poetry Miller was too imitative to be great. His personality, rugged and tender and earnest, is unable to show through the veils of Post-Romantic diction and stylism. In 1834 he published a book, "Scenes and Legends in the North of Scotland." In this the persons and places he had known in boyhood and during his years as a journeyman, odd stories that he had gleaned while living among "blackguards and gypsies" or among primitive, earnest men, were presented with vividness and tender sentimentality.

"The Old Red Sandstone," published in 1841, is Miller's earliest significant work of science. He had himself made important discoveries in that most indigenous of Scottish strata, had written "treatises" upon it. But now he looked back reminiscently over his contact with it and over all that its rich treasures of extinct life held for an imaginative mind. Of this he writes, one would say, without notes, without revisiting the spot; yet so deeply have the structures of rocks and the forms and successions of living things that are no longer found in any ocean, become part of himself that every sentence is convincing, luminous, impressive. He actually *loves* the Old Red Sandstone. His relation to nature and the knowledge of nature is above all a personal and emotional one.

Can his science be depended on? In a sense, no scientific writer remains a literal authority very long. New facts are discovered, old hypotheses remodelled, and the

[20] 1829.

best truth of yesterday is a very halting truth today, perhaps quite false tomorrow. Miller, furthermore, tended naturally to associate with those authorities great in his day, whom later discovery has dethroned: Buckland, Murchison, Agassiz,—yet he had the judgment also to take Lyell as his master. He knew his geology, especially that of Cromarty, and the Old Red Sandstone, which his efforts put upon the scientific map. One organism, the *Pterichthys Milleri,*[21] bears in its very name a monument to Miller's achievement as a discoverer. He was at one time President of the Royal Physical Society of Edinburgh, a distinction not lightly nor undeservedly won. His opposition to evolution, his insistence upon an almost biblical scheme of creation, and his own doctrine of a modified catastrophism were views shared then by the most capable men of science. "The scientific value of these works," observes Oliphant,[22] "is generally acknowledged" and the same critic adds, "their literary merit is hardly less marked."

For indeed Miller was "a thorough poet at heart" with "a power of picturesque and fervid prose." Buckland [23] vowed that "he would give his left hand to possess such powers of description as this man." Miller, it will be remembered, always combined literature and science in his great ideal. He had tried poetry, narrative, and the essay, and was a theological journalist before discovering his true calling. He had lived much and deeply, finding "life [24] itself a school, and Nature always a fresh study." There clung to him no shred of specialistic narrowness; he had a specialist's knowledge together with a knowledge of men and the human heart and the beauty of the natural world. In writing, he apologizes,[25] it is his purpose

[21] Miller's winged fish.
[22] "Victorian Age of Literature."
[23] "Encyc. Brit.," 9th ed., vol. 16.
[24] "My Schools."
[25] Preface, "The Old Red Sandstone."

to address the public as well as the specialist. And he knew the public and honored it, its hard hands and its reverent heart. He advised the stone mason to study geology. It is probable that his books have led thousands to scientific pursuits. For he did more than give advice; he "allured to brighter worlds and showed the way." Says Miller,[26] "much of the interest of a science such as geology must consist in the ability of making dead deposits represent living scenes."

That was pre-eminently his art: to make dead deposits represent living scenes. One example will here suffice: [27] "The pyramid . . . is inscribed from bottom to top, like an Egyptian obelisk, with a historical record. The upper and lower sections treat of tempests and currents; the middle is written, 'within and without,' with wonderful narratives of animal life; and yet the whole taken together comprises but an earlier portion of that chronicle of existences and events furnished by the 'Old Red Sandstone.' For instance, there are the fossils, creatures whose very type is lost, fantastic, and uncouth, . . . boat-like animals, furnished with oars and a rudder; fish plated over, like the tortoise, above and below, with a strong armour of bone; creatures bristling over with horns; others glistening in an enamelled coat, as if beautifully japanned." It was not for nothing that he said, "geology, of all the sciences, addresses itself most powerfully to the imagination; and hence one main cause of the interest which it excites."

Now, when the "Vestiges of the Natural History of Creation" appeared, and again the distasteful "ape-theory" of the origin of man exploded into the world of public thought, Hugh Miller felt called upon to do battle for the Lord. With the same frank, outspoken courage that he had shown in fighting church tyranny, he set out to break a lance against what he thought anti-religious

[26] "My Schools," p. 465. [27] "The Old Red Sandstone," p. 60.

views of science. He had never considered the Bible a geological text-book.[28] Furthermore his knowledge of science was entirely realistic, having been gained at first hand. Yet Miller felt everywhere the immanence of God, the personal Creator, in all of nature. His later books, "Footprints of the Creator" (1850) and the posthumous "Testimony of the Rocks" (1857) were written as a "summary of those evidences drawn from geology in favour of *revealed* religion" which it was "the chief portion of his peculiar mission to originate and establish." [29]

An element, at least, of Miller's own strength lies certainly in the frankness with which he sets forth the riches of his knowledge, even though it may seem to shed doubt upon the doctrine that he advocates. He was neither ignorant nor unfair; even in the heat of an argument he only rarely becomes sarcastic or personal. His own conclusions, too, were soundly formed. He always refused to admit "negative evidence" on either side of the question. Agassiz states [30] that "his generalizations have nothing of the vagueness which too often characterizes the writings of authors who have attempted to make the results of science subservient to the cause of religion."

In "Footprints of the Creator" Miller utilizes his deep familiarity with a special field to point a moral that is vital to all men. Among the ichthyolites, or fossil fish, of the lower Old Red Sandstone, there had appeared to be a definite progression—smaller, simpler ones below, greater, more complex ones above. But at Stromness he discovered an embarrassing exception, the *Asterolepis,* a large and highly developed *placoid* (or armored) fish, in the lowest layer; it must have lived before it could have been evolved out of its neighbors. Peculiarities in its preservation had kept earlier paleontologists from recognizing it for what it was. There were other exceptions;

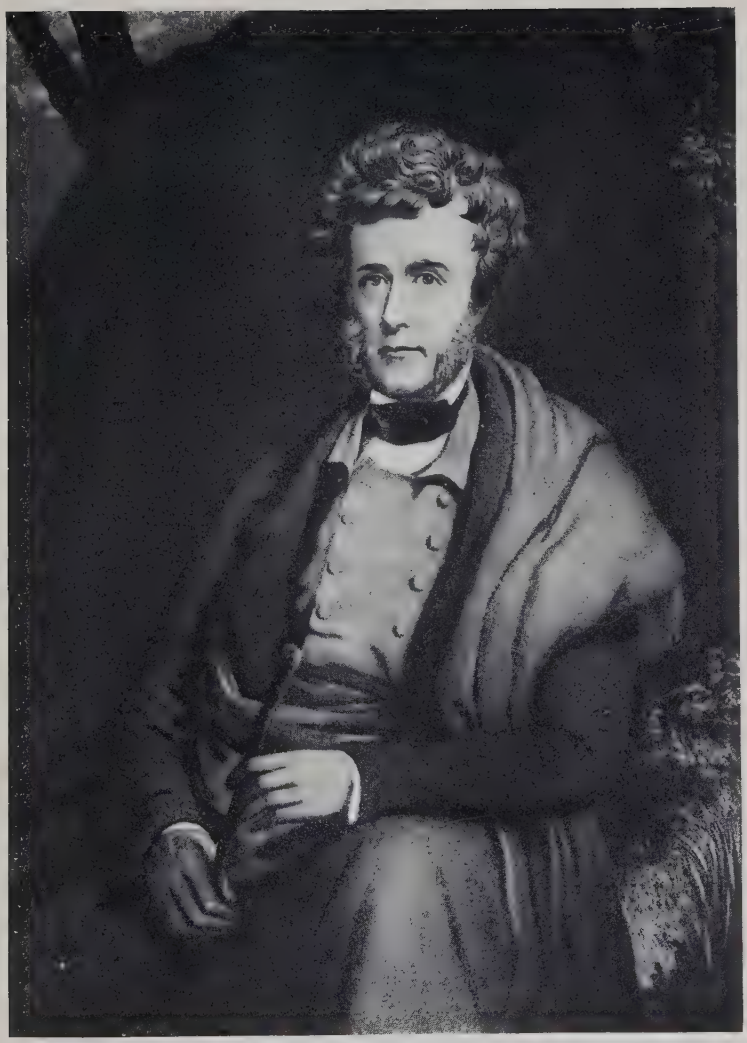
[28] See "Anti-geologists" in his "Testimony of the Rocks."
[29] Note by his wife to 7th ed., "The Old Red Sandstone."
[30] Note on the author; in 1865 Amer. ed., "Footprints."

there may have been exceptions innumerable; then why accept a hateful theory which has such weak spots in it as this?

Recognizing that some change certainly takes place in living forms, that different species do show connection and relationship, Miller has this unexpected argument to put forward: [81] "They exist as the monster *families* of creation just as among families there appear from time to time monster individuals. Among these degraded races that of the footless serpent, 'which goeth upon its belly,' has long been noted." Of such groups among the fishes he declares that "knowing their geological history better than that of any of the others, we know, in consequence, that the monstrosities did not appear *early* but *late,* and that the progress of the race as a whole, though it still retains not a few of the higher forms, has been a progress, not of development from low to high, but of degradation from the high to the low. It would be an easy matter for an ingenious theorist, not much disposed to distinguish between the minor and the master laws of organized being, to get up quite as unexceptionable a theory of degradation as of development." There has been a progress, he is sure, but it "gives no ground whatever for the belief that . . . the reptiles and fishes have been not only the predecessors, but also the progenitors of the beasts and of man."

Miller's attitude was a dual one, always scientific in at least one element. He argued with power and devotion [82] against a "monkish" view of the world with a history of only 6000 years. He was quite clear as to the geological evidence for the great age of the world. Likewise he knew (and knew why he knew) that the forms of life had appeared—he would have said "had been introduced"—on earth gradually and successively. He often talks like

[81] "Footprints," p. 187.
[82] See "Anti-geologists" in his "Testimony of the Rocks."



HUGH MILLER

an evolutionist, uses the very terms and approaches that an evolutionist would use.

This duality is his strength in the "Footprints"; but it seems to have grown at last into his undoing. It is more marked and far more painful in his last work, "The Testimony of the Rocks." This book, made up of twelve rewritten lectures, is full of thrills and shocks for the true Millerian. The author, who heretofore balanced neatly the two burdens of religion and of science, now staggers under them. He has effected a thorough reconciliation, based on separating the two, but it does him little good, and he knows it. He becomes more and more violent—on both sides and against both enemies.

His intentional and reasoned position is expounded in Lecture IX, on "The Discoverable and the Revealed." Here Miller maintains that Scripture is inspired only in its morality; its science is mere metonymy, primitive exaggeration, which we are prone to misunderstand. "And,[33] on the other hand, the great truths, physical in their bearing, to the discovery of which science is fully competent, God did not reveal, but left them to be developed piecemeal by the unassisted human faculties." Creation took place, not in six days but in six ages, species succeeding one another progressively. The Noachian Deluge [34] was a local flood due to submergence of the steppes of Astracan when that was the seat of the whole human race; the Ark contained only the animals peculiar to that locality: "Between the Word and the Works of God there can be no actual discrepancies."

"Scripture draws practically a broad line between the two modes; and while it tells man all that is necessary to his wants as a religious creature, it does not communicate to him a single scientific fact which he is competent to find out for himself."

But he is severe, even abusive, toward the embarrassing

[33] "Testimony of the Rocks," p. 372. [34] Lectures VII and VIII.

"infinite series" idea of the old "infidels," and more so toward the development hypothesis, which he calls "the philosophy of Topsy"—that species, like the dusky child, were not created but "just growed." Like the dreams of the dark ages, "it is equally a dream, and can have no place assigned to it among either the solid facts or the sober deductions of science. If true, it would be capable of proof; and so, if it cannot be proven, it is only because it is not true. . . . There is so much material evidence. . . . But no such genealogy can be formed. There are no intermediate species, no connecting links, no such connected series of specimens as enables us to trace a trilobite through all its metamorphoses from youth to age. All geologic history is full of the beginnings and the ends of species,—of their first and their last days; but it exhibits no genealogies of development." The Lamarckian, in short, is a "mere pretender."

But so is the "anti-geologist" as well, such as the anonymous "Clergyman of the Church of England" who in 1853 published "A Brief and Complete Refutation of the Anti-Scriptural Theory of Geologists." This man held that "fossils were not necessarily animated structures," that a carboniferous fossil tree, bent over at a height of ten feet, "*seems to have been created on purpose to silence the* HORRID BLASPHEMIES *of geologists.*" So was the Dean of York, who, speaking before the British Association,[35] had referred all geological phenomena to the great flood of Noah. It is with bitterness that Miller argues against these "anti-geologists" and with stinging clarity punctures their pretensions. He had found a sane middle ground of belief for himself, which had room for faith in revelation as well as for confidence in the methods and results of science. But he had not attained the peace which should have come with this achievement, for extremists on both sides, instead of closing ranks under his

[35] 1844, Glasgow.

moderate banner, were growing more and more extreme. Poor Miller found himself not the healer of a breach, but a solitary man at war with both parties, like the bat in the fable which was neither bird nor beast. . . . And then, one night in 1857, after sitting up late making some corrections in the text of his "Testimony of the Rocks," Hugh Miller took out his revolver and sent a bullet through his brain. The autopsy showed symptoms of what was then called "brain-fever," and this might alone have been sufficient to account for his suicide. Furthermore he had been unwell of late, and for many years had worked too hard even for his exceptionally powerful constitution. All these are real enough causes, but it would be a fascinating study for one of our psychologist biographers to determine which was *the cause*. May it not have been (this is a mere suggestion) the emotional conflict indicated in his last work, the internal war between the two halves of a spirit that was always consciously and essentially double, which at last drove that passionate and candid mind to find life no longer a possibility?

How shall his work be estimated? The same double character is in evidence here as elsewhere. For instance, in a letter [36] Charles Lyell declares "J. Hooker is amused with H. Miller's botany" but adds "his book is full of good matter." Another writer [37] comments thus: "So far as the author's observations bear on real points of geology and paleontology, they are characterized by his well-known acuteness and power of illustration. Yet throughout the whole we cannot but observe that the polemical spirit and avowed theological bias with which it is written cannot but weaken the authority of many parts of his

[36] To "L.H." (Leonard Horner?) and dated 8 Apr., 1857. The manuscript of this letter is pasted in the Kensington Museum copy of "Testimony."

[37] Rev. Baden Powell in "The Unity of Worlds and of Nature" (2d ed., 1856) criticizing "Footprints."

physical argument." The most sympathetic and understanding characterization of Miller is rather a personal one by Dr. John Brown.[88] It is "a tribute to that remarkable man, who stands alongside of Burns and Scott, Chalmers and Carlyle, the foremost Scotsmen of their time—a rough, almost rugged nature, shaggy with strength, clad with zeal as with a cloak, in some things sensitive and shamefaced as a girl; moody and self-involved but never selfish; full of courage, and of keen insight into nature and men, and the principles of both, but simple as a child in the ways of the world; self-taught and self-directed, argumentative and scientific, as few men of culture have ever been, and yet with more imagination than either logic or knowledge."

[88] "Notes on Art" in *"Horæ Subsecivæ."*

CHAPTER X

ANATOMIST AGAINST PHILOSOPHER

(Owen and Spencer)

In reading Miller's works, one is struck by the many resemblances between his view of the world, its making, and its creatures, and that of a very different individual, Sir Richard Owen.* Sir Richard was not an unworldly and intense primitive like Miller, but a polished man-of-the-world, capable executive, thorough anatomist, and prolific writer. As director of the Natural History departments of the British Museum, he did much to spread abroad a knowledge of Nature, and he built up what is now one of the finest institutions of its kind in the world.[1] His restoration of the *dinornis,* an extinct flightless bird of gigantic size, with but part of the bones of the foot as a clue, has now become a classic legend in the mythology of science. Men as great—and as unlike—as Miller and Agassiz looked upon him with awe. For many years his works on anatomy were authoritative, and they are still important.

Yet in the history of scientific progress, Owen is one of the villains, the adversaries, the opponents of advance who look to the past rather than to the future, who struggle hopelessly and often meanly against the inevitable forward march of our comprehension of nature. He was, says Dr. Dorsey,[2] "the greatest anatomist in England and a commanding figure in the scientific world—but so jealous of his own views that he could see no other." He

* (1804-1892.)

[1] The Natural History Museum, Kensington.

[2] "The Evolution of Charles Darwin," p. 188.

had come early into the field with views of his own, very definite ones, and his eminence made it seem essential that he oppose contrary theories. In youth a pupil of Cuvier's, he attended all sessions of the famous discussion of 1830 between his master and Geoffroy Saint-Hilaire, and has left a careful account [3] of the chief ideas mooted, the arguments that were rallied, and his own reactions. Feeling that Geoffroy's ideas were "too metaphysical," he agreed with his master in all points (but one), for "Cuvier held the work of organization to be guided and governed by final purpose," whereas his opponent "Geoffroy denied the evidence of design."

Owen himself insisted again and again upon the evidence of intelligent, even omniscient and providential, design in the structure of all forms of animals. He was not exactly an opponent of evolution as such, for his deep anatomical learning showed him too many homologies and affinities among the various species even among different genera and orders of animal life for him utterly to deny all relation between them. In fact, years before the "Origin of Species" appeared, Owen was busily engaged in expounding his own not unlike theory of "derivation." In 1846, for example, he issued a large and sumptuous work by the "desire and . . . liberal aid of the British Association." This very official work, entitled "A History of British Fossil Mammalia and Birds," already indicates the direction that Owen's thought was to take in regard to the great question of origins. He argues with unmistakable vigor against the "common notion [4] . . . that all the fossil remains of quadrupeds not now existing in our island had been brought hither in a single catastrophe," such as the great flood. He mentions certain fossils that "bespeak the great advance of animal life" and calls the *Acerotherium* "*a link* connecting

[3] "The Anatomy of the Vertebrata," p. 786*ff*.
[4] Introduction, p. xx.

Palæotherium with Rhinoceros." Inquiring how animals came to England, he doubts their [5] ability to swim "a tidal current of sea, twenty miles in breadth," adding that "the idea of a separate creation of the same species of mammalia which existed on the Continent, in and for a small contiguous island, will hardly be accepted." [6] Likewise he doubts "that they all simultaneously perished by a sudden and violent catastrophe, like that which Cuvier deduced from the phenomenon of the frozen Mammoth."

In other words, as early as 1846 Owen had gone as far as Lyell in visioning the world we know as the product of a long process of development. On the basis of his own knowledge of anatomy he had quite rejected the old tradition of a single creation and a single great catastrophe. But he had not given up the idea of creation as such. On the contrary, to his theory a constant—a never ending—series of real creations was indispensable, and in each he saw the immediate act of a supernatural intelligence.

It is interesting to compare the tone of his earlier writings with that of the books he issued after evolution had become an important issue. Essentially, it seems, his ideas remained unchanged, but, by simply sticking to his story through thick and thin, Owen was transferred willy-nilly from the liberal camp to that of the conservatives. What had been very advanced in 1846 was quite the opposite two decades later. And some sense of his altered position changed the spirit of Owen's writings. Instead of the urbane ridicule with which his earlier works anoint the reactionaries, his later books spurt vitriolic contempt upon the innovators.

His own explanation of the origin of the forms of life is made increasingly clear in a succession of works. One of the earliest of these, "On the Archetype and Homologies of the Vertebrate Skeleton," * is based upon a lecture

[5] "Anatomy of the Vertebrata," p. xxiv. [6] *Ibid.*, p. xxviii.. * 1848.

before the British Association and attempts to meet the problem from the viewpoint of anatomy. This was Owen's special field, and it is here that he was strongest. Though he had "previously yielded implicit assent" to the ideas of "the immortal Cuvier," a suggestion by Oken —that the skull is but a modified vertebra—impressed him so forcibly as to give a new direction to his thinking. He now saw all vertebrate animals as mere variations on a single theme, so to speak. Every bone seemed but an altered vertebra; every vertebrate form seemed similar to other forms in underlying structure and in the *homology,* or essential similarity, of many parts. He defines a homologue as "the same organ in different animals under every variety of form and function." Thus the foreleg of the horse, the arm of man, the wing of the bat, the flipper of the seal, and the paddle of the dugong are strictly homologous, while the wings and legs of insects are not at all homologous to those of birds. Underlying all these various instances, said Owen, there must be some *fundamental idea,* such as the real ideas of Plato's system, existing in the mind of the Creator. And this fundamental idea, this ideal or model vertebrate, he called the Archetype. It was not an altogether new or original theory. Goethe had had some such conception in mind when he spoke of the "Urthier." But Owen added to that philosophic notion a well-stocked armory of facts about the bones and organs of many animals. He even with no slight daring reconstructed a sample of the Vertebrate Archetype and did not flinch from discussing [7] "Man, the highest and most modified of all organic forms" in whom "we find the vertebrate pattern so obviously retained . . . and the mammalian modification of it so closely adhered to" . . . that the reader marvels to find the author avowing himself no evolutionist.

The book is not effectively written except in spots.

[7] "On the Archetype," p. 132.

Owen was an unequal writer, at times high-flown and stylistic, again abruptly anatomical. Yet he was by no means devoid of literary gifts; and his oral "discourses" were marked by the rhetorical flights that audiences at that time seem to have delighted in. One of these—"On the Nature of Limbs"—discusses the same topics in a more popular and attractive vein, and incidentally a more philosophical one. The "popular" ambitions of this discourse are quite freely avowed in the exordium, in which the author declares that he might have entitled it "On the General and Serial Homologies of the Locomotive Extremities"; "but," he laments, "such a title would have been comprehended only by anatomists." Even the Royal Institution, it seems, was "a more general audience" than could have profited by so technical a treatment. "On the Nature of Limbs" is no spoon-meat for babes, but it is a thought-provoking theoretical exposition which can be understood and enjoyed by educated persons who are not expert anatomists.

This essay elaborates the concept of homology, stressing and illustrating "that essentiality which it (any organ) retains under every modification of size and form, and for whatever office such modifications may adapt it" . . . "in its relation to a predetermined pattern, answering to the 'Idea' of the Archetypal World in the Platonic cosmogony." Writing fluently and spiritedly, he goes on to show "that the arm of Man is the fore-leg of the Beast, the wing of the Bird, the pectoral fin of the Fish . . . " that it belongs jointly to the bat and the mole save only that [8] "the chief change is this—whatever is elongated and attenuated in the bat is shortened and thickened in the mole," since "the [9] instrument must be equal to its office." . . . "The teleologist would rather expect to find the same direct and purposive adaptation of the limb to its office as in the machine. A deep and

[8] "Nature of Limbs," p. 13 (1849). [9] *Ibid.*, p. 9.

pregnant principle in philosophy, therefore, is concerned in the issue."

That deep and pregnant principle is gradually built up; at last [10] we see that " . . . when this fitness is gained . . . by a structure which at the same time betokens harmonious concord with a common type, the prescient operation of the One Cause of all organization becomes strikingly manifested to our limited intelligence." In this sentence Owen can be recognized as in that worried state of "viewing with alarm" which so often repels readers from the books of conservative thinkers. His agitation grows worse as he confesses himself unable to find any reason for *homologies* in the doctrine of final causes, adding [11] as an ultimatum, " . . . if the principle of special adaptation fails to explain them, and we reject the idea that these correspondences are manifestations of some archetypal exemplar on which it has pleased the Creator to frame certain of his living creatures, there remains only the alternative that the organic atoms have concurred fortuitously to produce such harmony."

This is the true "*Pudels Kern*" of Owen's doctrine. It strikes the keynote, also, of his mentality. Afraid—intellectually afraid—to face the chaotic implications of a purely naturalistic theory of life, yet thoroughly aware of the striking filiation of species with one another, he fled to the protecting shadow of a compromise: the doctrine of the "derivation" of all species from an archetypal pattern in the mind of the Creator. Thus the early Victorian naturalist avoided the Scylla of a no longer tenable adherence to the complete separateness of all species and the Charybdis of a loss of faith in an all-powerful Creator.

Owen argues further that "the Divine mind which planned the Archetype also foreknew all its modifications," closing with a summary of the derivation idea so

[10] "Nature of Limbs," p. 38. [11] *Ibid.*, p. 40.

nearly like that of evolution and so typical of his literary style with its ornate majesty almost overreaching into bombast, that it seems well to quote it in full:

"To what natural laws or secondary causes the orderly succession and progression of such organic phenomena may have been committed we are as yet ignorant. But if, without derogation of the Divine power, we may conceive the existence of such ministers, and personify them by the term 'Nature,' we learn from the past history of our globe that she has advanced with slow and stately steps, guided by the archetypal light, amidst the wreck of worlds, from the first embodiment of the Vertebrate idea under its old ichthyic vestment, until it became arrayed in the glorious garb of the Human form."

Indeed such was the most advanced view acceptable to a world as yet ignorant of the natural laws of descent and very loyal to a theological view of the universe. Save for its humility in the face of Divine power, that peroration might *almost* have been Huxley's, even in its grand forensic manner. So far could Owen go—but no further. Not until natural selection had been recognized and named and illustrated and all but proven, was it possible for anyone to go much beyond that point.

One other leading idea was contributed by Owen to the vexed problem of what species are and where they come from. This was set forth in some detail in two lectures [12] dealing with the classification of the mammalia. Since the days of Linnæus the teeth had supplied a most important means of grouping the main divisions of the highest class of animals. This scheme had several inconveniences, and Owen himself, though a master of its technique, was dissatisfied with it. In 1857 he devised a new

[12] "On the Characters, Principles of Division, and Primary Groups of the Class Mammalia," read in 1857; pub. *J'nal Proc. Linnean Soc.*, 1858, and "On the Classification and Physical Distribution of the Mammalia," the Sir Robert Reade lecture (May 10, 1859) at the Senate House, Cambridge, pub. (by Parker) in 1859.

classification based on the types of brain possessed by the various groups. His method made use of his own discovery—in 1836—that kangaroos, wombats, ornithorhynchus, and echidna lack what is called "the great commissure" of the brain. It had one other tremendous advantage; it enabled Owen to describe "the genus *Homo* as not merely a representative of a distinct order, but of a distinct subclass, of the Mammalia," for which he proposed the name of Archencephala, or over-ruling brain. About this last statement one of his fiercest battles with Huxley was destined to rage.

The second of these two lectures was delivered after the first paper on natural selection by Darwin and Wallace had become public. Owen's angry and hostile tone in this otherwise finely composed essay seems to show his awareness that the great biological war was at last under way. So does the addition of an appendix "On the Extinction and Transmutation of Species" and another "On the Orang, Chimpanzee, and Gorilla." But he has evidently not yet grasped the idea of Natural Selection, for he argues hotly against the possibility of change being caused by environment and effort. . . . Darwin was then actually in the field, and Owen was hurling a heavy barrage against dead Lamarck and dead Saint-Hilaire.

His oratory must indeed have been powerful, but for modern readers it has lost some of its old force through the increasing tendency of science to concern itself only with the "knowable." Owen habitually began or ended his discourses with some religious reflection and at times drew conclusions in science more from faith than from observation. The present address works up to a climax in this form: "It is He that hath made us; not we ourselves. . . . The supreme work of Creation has been accomplished that you might possess a body—the sole erect—of all animal bodies the most free—and for what? For the service of the soul . . . temple of the Holy Spirit.

Defile it not . . . " and so on. . . . His stout Anglican hearers must have thrilled and admired and been reassured, and Owen must have known the satisfaction of success. For the moment he drops out of sight; when he reappears, it will be as the tenacious but doomed champion of a retreating Old Guard, an academic army that dies mentally but never surrenders to a new truth.

Quite an opposite personality was that of Herbert Spencer,* who began adult life as an engineer and closed it as the grand prophet of a "Spencerian" school of philosophers. Unlike Owen, who was a most useful digger in dusty osteological graveyards and might have been happy all his life by the simple expedient of avoiding all theories and all controversies, Spencer was not a specialist in any field but primarily a keen publicist and polemist in whatever might happen to be most hotly contested at the moment. Mathematician, economist, biologist, metaphysician, radical agitator, anthropologist, psychologist, he took, like Bacon, the whole of knowledge to be his province. Like Bacon, too, he was supremely the grand marshal, the commander-in-chief of his hosts of learning, essentially the classifier, strategist, organizer of fact and thought. And he had more daring, more sheer intellectual contempt for danger than Owen; he would rush to embrace a new idea the more eagerly just because it was new and perhaps explosive.

So it was natural and characteristic that at a time when Darwin was still devising experiments, testing effects, and pondering conclusions and meanwhile keeping his own counsel, while Owen was wavering between skeletal minutiæ and theological generalizations, Spencer jumped with both feet into the thick of what he hoped would prove a fray. This he did in a magazine article on "The Development Hypothesis," [18] a stirring, logical article, three columns in length, proving in the most convincing

* (1820-1903.)

[18] "The Haythorne Papers, No. II," in *The Leader*, March 20, 1852.

manner, to the complete satisfaction of the author and his coterie of liberal readers, that Lamarck's theory of transformism is at least probable, while the conventional belief in special creation must rest for its acceptance upon other grounds than human reason.

The entire short essay is one vivid argument; it reads like a stenographic report of a brilliant debate—one side of a debate. When not too technical, Spencer could catch the ringing, challenging note that many people admire. "Those who cavalierly reject the theory of Lamarck and his followers," he declaims, "as not adequately supported by facts, seem quite to forget that their own theory is supported by no facts at all." He estimates that there are and have been a total of ten million species of animals and plants, and asks: "Is it most likely that there have been ten millions of special creations? or is it more likely that by continual modifications, due to change of circumstances, ten millions of varieties may have been produced, as varieties are being produced still? One of the two theories must be adopted. Which is the more countenanced by facts?"

The facts he chooses, the illustrations he cites, are the very ones best calculated to overwhelm a reader with the sense that what the writer advocates is the only possible truth. A parabola may grade off into a circle by gradually inclining the plane that cuts the cone. "A tree differs from a seed immeasurably in every respect—in bulk, in structure, in colour, in form, in specific gravity, in chemical composition; differs so greatly that no visible resemblance of any kind can be pointed out between them. Yet is the one changed in the course of a few years into the other—changed so gradually that at no moment can it be said—now the seed ceases to be, and the tree exists." Again and on a loftier plane—"Surely, if a single structureless cell may, when subjected to certain influences, become a man in the space of twenty years, there is nothing absurd in the hypothesis that,

under certain other influences, a cell may in the course of millions of years give origin to the human race. The two processes are generically the same, and differ only in length and complexity."

His explanation of the method is that changed surroundings produce changed habits and hence a changed use of organs. This, declares Samuel Butler,[14] "is the whole theory. . . . Volumes may be written to adduce the details . . . but I fail to see how anything essential can be added." One is tempted to remark that Butler's failure to see proves nothing save his own utter lack of grasp of the real spirit of science, for details are not unimportant things to be "adduced" as an after-thought, but the flesh and blood of scientific knowledge, the plasma from which theory is educed, the touchstone by which hypothesis must be tested. Spencer's mind was in this not unlike Butler's. Though he had a conscious and wholesome respect for facts and details, what Spencer really gloried in was abstract, courageous, and far-spreading reasoning.

Even before the paper on "The Development Hypothesis," Spencer had thought about nature and had more or less approached evolution. In 1844 he published an essay * in the *Philosophical Magazine and Journal of Science,* in which he implied that an improvement in the quality of the air during past ages may have produced "the increased intensity of life and superiority of construction that has accompanied it." This essay is very logical, but very abstract and full of the most expansive, all-embracing theorizing. Indeed the editor saw fit to disavow it, declaring in a note, "We have inserted the foregoing communication because the inquiry to which it relates is one of extreme interest, and our correspondent's reasoning may excite attention to the sub-

[14] "Evolution, Old and New," p. 331.

* "Remarks Upon the Reciprocal Dependence in the Animal and Vegetable Creations as Regards its Bearing upon Palæontology" (1844).

ject; but we doubt whether his inferences are warranted by the known facts of Chemistry and Paleontology; we fear that his generalizations are at least premature."

Generalizations, mature or premature, were Spencer's peculiar and especial mode. Another essay [15] aims at enunciating "sundry laws of development and function which hold not of particular kinds or classes of organisms, but of all organisms." As an example of such law he cites "the relation between the activity of an organ and its growth. This," he maintains, "is a universal relation. It holds, not only of a bone, a muscle, a nerve, an organ of sense, a mental faculty; but of every gland, every viscus, every element of the body. It is seen, not in man only, but in each animal which affords us adequate opportunity of tracing it. . . . On this law are based all maxims and methods of right education, intellectual, moral, and physical; and when statesmen are wise enough to see it, this law will be found to underlie all right legislation." Here one can see the germ of a great part of Spencer's life-work, the synthetic philosophy. His most typical literary habit is illustrated also—the method of generalized detail, producing theses apparently rich in detail, of a sort that the scientific mind would not admit as such, but actually a complicated web of conclusions and generalizations.

His article on "Progress: Its Law and Cause" [16] is of especial interest here as being admittedly "the form under which the General Doctrine of Evolution [17] first made its appearance." Most persons have a merely superficial notion that progress consists in the multiplication of things that make man more comfortable. But Spencer demands of nature "what progress is in itself." There is,

[15] Published in *Nat'l Review*, Oct. 1857, as "Ultimate Laws of Physiology." In his collected essays, he restored the original name, "Trancendental Physiology."

[16] In the *Westminster Review*, April 1857.

[17] The capital letters are his own. This is significant.

he concludes, a necessary "advance from homogeneity of structure to heterogeneity of structure . . . this is the law of all progress . . . whether it be in the development of the Earth, in the development of Life upon its surface, in the development of Society, of Government, of Manufactures, of Commerce, of Language, Literature, Science, Art, this same evolution of the simple into the complex, through successive differentiations, holds throughout."

Thus the plan was drafted, and the remainder of Herbert Spencer's life was to be devoted to the execution of it, to illustrating and developing the first generalization, to evolving from it generalization upon generalization, to arguing for it under a thousand heads. Only one vital factor was still to be added, and that—the idea of the survival of the fittest—had yet to be suggested, as it soon was, by Darwin under the name of *natural selection.* Does it seem unfair to Spencer thus to suggest a certain lack of originality? After all, he was not a scientist, not an artist, not an educator—not an expert in any of those fields whose harvests he threshes so lustily, save possibly in sociology and politics. It is curious, too, how much more vivid and respect-compelling his essays on these matters are than those in which he discusses natural science. It seems as though he had read widely and remembered everything that he read; then, with great mental energy and utter confidence in his own powers of mind, he reasoned upon what he had learned. His reasonings were his own, but in some measure they lacked —or at least today they lack—the sense of reality which firsthand, physical, sensory knowledge gives to the work of a genuine naturalist. Not only do his specific facts all seem borrowed; he does not care much for specific facts. His interest is all in conclusions. To him facts are, as it were, inconvenient annoyances, necessary but bothersome delays to the tremendous sweep of his general ideas. It

is not a mere casual happening that in one essay [18] he remarks: "Before comparing these conclusions with facts, let us pursue the reasoning a little further." Darwin could not have done things that way nor could Newton nor Lyell, nor Tyndall; nor could Spencer have done otherwise except by suppressing his true nature. He is often willing to make great assumptions and then reason hypothetically upon that basis, as when he expounds the Nebular Hypothesis, which at the time "had fallen into disrepute," and declares that this hypothesis, "if true . . . supplies one illustration of this law." Too readily he will be satisfied with one illustration. Admitting that the geological record is inconclusive evidence of organic evolution, he "cannot but think that, scanty as they are, the facts" bear out his idea. "Let us cite, in illustration, the one case of the *Vertebrata.* The earliest known vertebrate remains are those of Fishes; and Fishes are the most homogeneous of the Vertebrata. Later and more heterogeneous are Reptiles. Later still, and more heterogeneous still, are Birds and Mammals." Again—*one* illustration.

This part of the general doctrine, by the way, the organic law of development, was borrowed from the German zoölogist, von Baer. Spencer extended it so as to fit progress of all kinds. Seeking a cause for the progressive development which he could see everywhere, he was delighted to "predict that it has a high degree of abstractness; seeing that it is common to such infinitely varied phenomena." He salted the tail of that cause by posing a maxim with the desired "high degree of abstractness"; it ran thus: "Every active force produces more than one change—every cause produces more than one effect." Thus complications increase at an ever-accelerating rate. A state of homogeneity is, and must be, a state of unstable equilibrium, wherefore the cosmos rushes onward

[18] "The Nebular Hypothesis," 1858 (in *Westminster Review*).

toward the heterogeneity which is its goal. . . . And yet . . . and yet, "In all directions his investigations eventually bring him face to face with the unknowable . . . under all things there lies an impenetrable mystery."

It must be clear at last that Herbert Spencer, spokesman and seer of evolution though he might be, was not made by the great events of 1859. At that date he had reached early middle age. After an active young manhood he was famous within a limited circle of advanced thinkers and their enemies. But what is more important is that his mind had taken shape—a shape which it held thereafter both in the substance of his thoughts and the manner of his thinking. He was already an evolutionist, had already applied evolution to all the fields and activities that his extraordinarily fertile mind had chanced upon. It was "a tenable hypothesis," which was good enough for Spencer, but it was unsupported by facts and therefore ineffectual. "Out of this deadlock," he explains,[19] "we were released—in large measure, though not, I believe, entirely, by the Origin of Species." It was like the sun rising upon a bud; all that he already was, suddenly spread itself out and flourished.

[19] "The Factors of Organic Evolution," *Nineteenth Century*, April and May 1886.

PART III

DARWIN AND OTHER VICTORIANS

To know what you prefer, instead of humbly saying Amen to what the world tells you you ought to prefer, is to have kept your soul alive.

Robert Louis Stevenson.

We are as much strangers in nature as we are aliens from God.

Emerson.

Fearless inquiry tends continually to give a firmer basis to all true Religion.

Herbert Spencer.

All action by the mind is easy, if it is not subjected to the test of reality.

Marcel Proust.

The doctrine of evolution is neither Anti-Theistic nor Theistic. It simply has no more to do with Theism than the first book of Euclid has.

Thomas Henry Huxley.

One has attained a synthesis when one has put everything together so as to make of it a whole. One has achieved a style when one has put together a few things so harmoniously that for the time being nothing else seems to matter.

Joseph Wood Krutch.

A perception of the failure of things to be what they are meant to be lends them in place of the intended interest a new and greater interest of an unintended kind.

Thomas Hardy.

A fool, you know, is a man who never tried an experiment in his life.

Erasmus Darwin.

The scientific investigation of Nature strives to recognize the universal in the individual in order to come at last nearer to the basis of all things.

K. E. von Baer.

The most marked characteristic of Reason is Doubt.

Buffon.

CHAPTER XI

PATTERN OF AN IDLER

After all these instances, it might well be surmised that Darwin entered the arena as but one of a long procession. Historically this is quite true; psychologically, most misleading. All the tortuous incarnations of the evolutionary idea that have just been chronicled had led nowhere. Not one was grounded in enough facts. Not one of the writers had been able to devise a *vera causa*—a sufficient actuating force to account for the changes that so many believed in. Not one had told a plain story convincingly. Buffon intimated his views ironically. Old Dr. Darwin bedizened them with late Augustan rhetoric or obtruded them in fragmentary footnotes. Goethe and Spencer hit the theory off incidentally, cramming it into the intervals of other work. Lamarck and Saint-Hilaire thought clearly but not steadily, while Cuvier and his follower Owen played fast and loose with it, their influence on the whole being antagonistic. And there was no coherence among them. Several believed the idea to be original with themselves and even new. Meanwhile the orthodox view continued to be that each species had been separately created and was a real and permanent entity.

"I occasionally sounded not a few naturalists," says Darwin in his "Autobiography," [1] "and never happened to come across a single one who seemed to doubt about the permanence of species. Even Lyell and Hooker, though they would listen with interest to me, never seemed to agree. I tried once or twice to explain to able

[1] "Life and Letters," p. 71.

men what I meant by Natural Selection, but signally failed."

What such failure to be understood must have meant to a man of fifty, without a profession, whose life was devoted entirely to the "strong desire to add a few facts to the great mass of facts in Natural Science" can be easily imagined. He worked, as it were, in a vacuum, in a world apart, and it was only after his enunciation of the hypothesis that the rest of mankind moved into his world deciding that it was more real than their own. Even Huxley, who later became more Darwinian than Darwin, in 1857 considered [2] "that the evidence at present obtained does not justify a verdict either way."

Yet the time was ripe for the discovery. In some unconscious way the public mind had been prepared for the discovery which even advanced naturalists did not realize was coming. Lyell had driven catastrophism out of geology. Owen was talking vaguely of some mystical "derivation" of later and more complex species from earlier and simpler ones. Spencer had swallowed the transformism of Lamarck and, when not busy at bludgeoning the Comtean Positivists or riddling the inequities of the British social and economic structure, would relieve the tedium of life by a frontal attack upon standard taxonomy with its constant quibbles over whether a certain group was a real species or a mere variety. It was long since "the notorious 'Vestiges' " had stirred up popular interest and ecclesiastical wrath. In all conscience, in all reason, the mind of England, and indeed of the whole Western World, should have been ready. But it was not ready. When the explosion came, it was a surprise to everyone and a shock to most. . . . History is oddly illogical at times.

Never was the cause of an explosion a less explosive character than Charles Robert Darwin.* By descent,

[2] Spencer, "Progress," pp. 16-17.

* (1809-1882.)

habits, and inclinations he belonged to the conservative class of landed gentry. His father was a country doctor, settled at Shrewsbury—a man apparently of considerable practical wisdom but of no remarkable scientific attainments.[3] Genius in that family had skipped a generation, for the grandfather of Charles was the eminent poet, Dr. Erasmus Darwin. Indeed one recent biographer,[4] seeking to psychoanalyze the younger man, paints his father as a fool and something of a rogue so far as his treatment of the son was concerned, and depicts the successes of Charles Darwin as a sort of self-assertion or revolt against his father's tyranny, motivated by the presumed inspiration of his mother, who died when the boy was eight and whom he could scarcely remember. This seems straining the subconscious mind too far. Certainly Darwin's "Autobiography" and the other reminiscences and records of him contain very little about his mother, as was natural under the circumstances; his father is referred to often and always in terms of deepest appreciation tempered by fairness.

As a boy Darwin showed the collecting instinct so common among boys and, by a bent toward chemical experiment, earned the nickname of "Gas." But he was not clearly "cut out" for science from the first. As a medical student at the University of Edinburgh, he could not endure the experience of the dissecting-room, so he transferred to Cambridge to prepare for the Anglican ministry —the other respectable profession. At first he found geology inexpressibly dull. He had the same feeling for most studies and naturally enough became one of a sporting clique that rode much, hunted, and drank, studying only when an emergency arose.

[3] Nevertheless Robert Waring Darwin was the author of a paper "On the Ocular Spectra of Light and Colours" (Vol. 76, *Philos. Trans.*, 1785) which Goethe called "The most suggestive" (ausführlichste) that had appeared.

[4] George A. Dorsey, "The Evolution of Charles Darwin," 1927.

Indeed the sporting life seems to have been his gateway to science. He loved to hunt and unconsciously acquired an interest in the natures of dogs and of game birds as well as a curious eye for the structure of a terrain. His first appearance in print is a case in point: [5] "No poet ever felt more delighted at seeing his first poem published than I did at seeing in Stephens' 'Illustrations of British Insects,' the magic words 'Captured by C. Darwin, Esq.' " He had been introduced to beetle-collecting by a cousin, who was at Cambridge at the same time, and pursued it as a sport, becoming a fair entomologist before he had made noticeable progress in any other branch of science.

Then two things happened to him, and those two permanently directed his career. He read Humboldt's "Personal Narrative" [6] and Herschel's [7] "Preliminary Discourse," and he became a student of the Rev. J. S. Henslow, professor of botany. His simple and ardent nature, which till then had been untouched by any feeling deeper than a lusty enjoyment of the outdoors, was stirred and thrilled and captivated by the spell of the two great books about science; he literally worshipped that other rich personality who seemed to him science incarnate. Humboldt was then very nearly the Lord High Pooh-Bah of everything scientific. Having made tremendous discoveries in several fields as widely separated as meteorology and anthropology, and having written and published with tireless zeal, the aging baron was the recipient of "that which should accompany old age: as honor, love, obedience, troops of friends." His "Personal Narrative" of his travels was bound to be much in the public eye and must have reached the Cambridge undergraduate trailing clouds

[5] Autobiography, p. 43, "Life and Letters."

[6] Humboldt (Baron) Alexandre de, "Personal Narrative of Travels to the Equinoctial Regions of the New Continent, during the years 1799-1804," translated by Helen Maria Williams, 1818-1819.

[7] Sir John F. W. Herschel, "A Preliminary Discourse on the Study of Natural Philosophy" (for the "Cabinet Cyclopedia," 1830).

of glory which intensified all its real values beyond computation. Today Humboldt seems scarcely so attractive a character. He was altogether too important and, what is worse, he knew it. The style of his writing often grows pompous and turgid; his translator cited "the faculty he possesses of *raising the mind to general ideas,* without neglecting individual facts."

In the early nineteenth century, readers did not resent Authority but respected it. If Humboldt laid down the ultimate truth, at any rate he did know much and he had some desire to write interestingly. "While he appears only to address himself to our reason, he has the secret of awakening the imagination, and of being understood by the heart." Doubtless young Darwin found his pages fascinating. An ideal was born in him, an urge to see the world of nature, to travel in romantic Teneriffe and the high Cordilleras, to walk amid the solemn profusion of a tropical forest, to "add a few facts to the great mass of facts in natural science." Long afterward, when he was living amid the very scenes whose description by the great man had first thrilled him, he wrote home that it was beyond his powers to depict them [8] and advised his family to read Humboldt but "skip the scientific parts." For himself, he did not skip the scientific parts; they became the foundation of his life.

In England there was at the time no name more honored in science than that of Herschel. Old Sir Frederick William, that eccentric, devoted, German-born music-master who ground the lenses and polished the reflector for his own telescope, and then became the foremost astronomer of many generations, adding much to our knowledge of the construction of the universe, had been gathered to his ancestors. In his stead, his son, Sir John, a man of similar intelligence though slenderer originality, gracefully wore his inherited honors. He reëxamined and

[8] "Life and Letters," Vol. I, p. 204.

extended his father's discoveries, making that view of the heavens complete by observing the southern sky during a long residence at the Cape of Good Hope. He lectured often, before both learned audiences and popular ones, and wrote freely in a smooth, platform style. One of these works was his "Preliminary Discourse on the Study of Natural Philosophy," which, says the "Encyclopedia Britannica," "possesses an interest which no future advances of the subjects on which he wrote can obliterate from the attention of thoughtful men in any age." Dr. John Brown,[9] beloved author of "Rab and His Friends," calls Herschel's work "first rate, and written with great eloquence and grace." It was a general treatment of the philosophy of science, the ideal theme for a man of Sir John Herschel's temperament, for it allowed him to be learned and oratorical by turns, to spice abstract laws with figures of speech, to point to tabulations and diagrams, yet to utter flourishes and fanfares. He had, declares an anonymous reviewer, writing in the *Quarterly*, "a striking mode of presenting recondite truths, and an imaginative vivacity which has its charm no less than the brilliant eloquence of the great naturalist of France" (meaning Cuvier, of course). The "Discourse" aimed to present three main ideas: "the dignity and uses of physical science, . . . its general principles and method," and the "peculiar principles of the different departments." It was thus in the main a contribution to the much abused field of popular science. The elementary character of much of its contents, the extensive rather than intensive treatment which it displays, the emphasis on practical results of applied science, the swelling optimism with which the author surveys progress and achievements, the conscious embellishments, the frequent emotional appeals—all mark it as belonging to the popular wing of scientific writing.

[9] "Horæ Subsecivæ," essay entitled "With Brains, Sir."

Be that as it may, it profoundly moved and roused young Darwin. Of Herschel he declared that "every word that he uttered was worth listening to" and added[10] that this book and Humboldt's "stirred up in me a burning zeal to add even the most humble contribution to the noble structure of Natural Science. No one or a dozen books influenced me nearly so much as these two."

This statement, unusually emphatic from the pen of a cautious, reserved, and moderate man, should be digested well by schools and teachers of science. The books which led Darwin to a scientific career were not excellently thorough text-books, logically arranged and full of definitions and classifications, but a "Personal Narrative" and a "Preliminary Discourse," the one a sandwich of facts between layers of travel and adventure, the other an inspirational manifesto on some of the most far-reaching and indeterminable factors of scientific thought. If anyone fears that study of such works might fail to develop habits of accuracy and clear thought, let it be remembered that Darwin, more influenced by these two books than by any other dozen, grew into a perfect *beau ideal* of the investigator, patient, careful, resourceful, logical, methodical, and (above all) intellectually honest.

The other powerful influence at this critical point was his admiring friendship with J. S. Henslow, professor of botany. Sickened by too many tiresome lectures at Edinburgh, he naturally kept away from them at Cambridge. Somehow or other he stumbled into Henslow's lectures which he "liked much for their extreme clearness, and the admirable illustrations." Field excursions, to study the rarer plants of the district under this admirable guide, "were delightful." First visiting the weekly ceremonies known as "open house," the student eventually became a friend of the professor; he was known as "the

[10] Autobiography in "Life and Letters," p. 47.

man who walks with Henslow." He reverenced Henslow's vast knowledge of all sorts of matters but not more than his righteousness, unselfishness, and benevolence. Through Henslow he met several eminent men, including the majestic Dr. Whewell.[11] It was through Henslow, too, that he was induced to study geology—against which science he had an old antipathy. Under Professor Adam Sedgwick, an eminent scientist of the old school, friend of Wordsworth, Darwin soon developed an enthusiasm for geology. It was in this field that his earliest original work was done. He grew in favor with Sedgwick, who took the youth with him on a geological tour of North Wales.

[11] Author of "The History of the Inductive Sciences," etc. See Part IV, Chapter XX, below.

CHAPTER XII

THE "BEAGLE" ADVENTURE

His return from this tour brought the young graduate into the greatest adventure and by far the most important formative experience of his life. He was offered the post of naturalist aboard H.M.S. *Beagle* about to set forth on a cruise of exploration around the world. How he nearly lost the appointment through his father's objections and again through the captain's ideas of interpreting physiognomy is fascinatingly narrated in the "Autobiography." Fate—and the inmost desire of his nature—was not to be cheated; in December 1831, being then in the twenty-third year of his life, Charles Robert Darwin, naturalist, sailed out of Devonport on board H.M.S. *Beagle.**

At the first rough weather he was sea-sick and never overcame a proneness to this affliction. Yet so greatly did the love of learning nature's ways lure him on that for five years he retained an enthusiasm for the expedition. On first seeing the peak of Teneriffe above the mist, on first walking through the same Brazilian forests that had stirred the imagination of the great Humboldt, young Darwin, too, was deeply moved. Yet his love of science was pragmatic; it did not evaporate in vague emotions. He worked hard during those five years, experienced deeply—so far as we know, in a purely intellectual way—learned tremendously, made himself into what he was to be, and laid the basis for a revolution that has changed every phase of thought and is still vigorously at work.

In the cramped chart-room of a scarcely sea-worthy,

* The voyage ended October 2, 1836.

heaving, old sailing-vessel that weighed a scant two hundred and forty-two tons, he sat, when he was well enough to sit, writing industriously at his journal. He early developed an extremely methodical way of working—he had to, in those quarters—a system which remained a life-long asset. Whenever the ship landed, the "fly-catcher," as he was called, was on shore quickly, armed with a simple kit and with writing materials, full of his old energy and eager to study the productions of the land. He worked hard; the mere record of his achievements is enough to show this. Everywhere he went, he studied the geological formations that appeared, the plants and the animals. He seems to have had no diversions, no amusements other than learning all he could about everything he came across. When the ship was engaged in sounding along some coast, he would take horse and explore the country, living among savages and primitives for days or even weeks. In this way he made a general survey of the natural history of the Cape Verde Islands, South America, the Galapagos Islands, the various South Sea groups, and Australia. The *Beagle* expedition had been planned for scientific purposes, and Captain Fitz-Roy had himself created the post of naturalist, so Darwin was spared at least the discouragement of constant misunderstanding by his colleagues. Of course, there were other difficulties.

It will be remembered that Lyell's monumental "Principles of Geology" had been but newly issued in 1830. As a farewell gift to amuse tedious hours on board, Henslow had given Darwin a copy of that great work, with the suggestion that he read it carefully, but by no means believe it. He "studied it attentively" and, he records,[1] "The very first place which I examined, namely St. Jago in the Cape Verde Islands, showed me clearly the wonderful superiority of Lyell's manner of treating geology,

[1] "Autobiography," p. 52.

compared with that of any other author, whose works I had with me or ever afterwards read."

Lyell's "wonderful superiority" consisted, apart from a literary style ideally adapted for his purpose, in a strictly realistic attitude toward all geological phenomena. He assumed that all effects had been produced by such causes as are still at work. He refused to admit that any unusual catastrophes had played large parts in making our globe, and thus became the leading figure in the uniformitarian movement. Now Darwin had never heard of this doctrine before, having studied under Sedgwick, who to his dying day accepted only a part of it. But he tried out the new idea. He examined St. Jago, and saw clearly "the wonderful superiority of Lyell's manner of treating geology" when tested not by authority, learning, and logic, but by application to facts in their native environment—the one truly scientific test. Thereafter Darwin was a uniformitarian, which is to say that he was bound to seek a natural, verifiable explanation for every phenomenon, that he could not rest satisfied with a tradition that in former times there had been a revelation of a still more ancient miracle. This was unconscious in him at the time, as it long remained unconscious in Lyell.

He was then no evolutionist. He had read as a child his grandfather's books, in which poetic and philosophic guesses are ventured as to the origin of species by descent from preëxisting forms, but he was not impressed save to note how far old Erasmus anticipated "the erroneous grounds and opinions" of Lamarck. He was still a believer; his faith passed from him only later and so gradually that there was no spiritual crisis such as many of his age-mates underwent. He had learned and still held the idea that each species was as real and distinct an existence as an individual is and more permanent, that in some dim way each had been created and set in its own land,

where it multiplied after its own kind and would continue to do so forever more.

But his work in South America brought many rare opportunities for study. Some of them led to alarming questions, to disconcerting conclusions. Whatever they were, he seized them. Thus his "Journal" [3] records: "Having heard of some giant's bones at a neighboring farmhouse on the Sarrandis, a small stream entering the Rio Negro, I rode there accompanied by my host, and purchased for the value of 18 *d* the head of the toxodon." This extinct mammal, whose remains are found in no other part of the world, shows certain resemblances in structures and detail to other mammals now living, in South America and nowhere else. The same is true of other kinds of animals: the mylodon, whose remains he found in startlingly fresh condition and which shows an affinity with the sloth, a huge extinct armadillo whose degenerate descendants still roam the same region, and many another as well. Why are there these correspondences? What more natural than to suppose that the modern species are simply descended, with alteration, from the similar yet different ones whose bones are dug out of the soil of the same region?

He was not yet ready for so affirmative an opinion. Evolution had by no means become his sole interest. This was the great seed-time of his life. He travelled and he saw, he discovered new facts, new species, thought new thoughts, asked old questions; and all of this went down systematically into his carefully prepared notes. . . . And then he remarked another significant and stimulating fact. As the vessel made its way down one coast of South America and up the other, he observed that allied species of a single genus replaced one another in "the economy of nature." He began to be aware of the vastness of plant and animal life, of the tremendous number

[3] "Journal of Researches," p. 155.

of different forms that there are, of the slight differences separating some kinds from others so that the whole varied population of the world seems to be one connected network, of the intimate relation between certain creatures and the conditions under which they live. Had each slightly different species been separately created and then sent to live a few miles from the next, or had it grown thus, from being the same at first, because it lived a little differently?

This was most clearly seen when his ship, having fought the head-winds of the Horn and glided north into the Pacific, touched at that "world's end," the Galapagos group of islands. Oceanic islands have regularly been an interesting field for the naturalist. The barriers on all sides, by interfering with the free "immigration" of species from without, make such places unique in character. This is especially noteworthy in the Galapagos, whose very rocks are, geologically speaking, of extremely recent making. Says Darwin: [8] "Most of the organic productions are aboriginal creations, found nowhere else; there is even a difference between the inhabitants of the different islands; yet all show a marked relationship with those of America, though separated from that continent by an open space of ocean between five hundred and six hundred miles in width. The archipelago is a little world within itself or rather a satellite attached to America, whence it has derived a few stray colonists, and has received the general character of its indigenous productions. . . . Hence, both in space and time, we seem to be brought somewhat near to that great fact—that mystery of mysteries—the first appearance of new beings on this earth."

While he explored the pampas, those southern equivalents of our Middle Western prairies, he heard rumors everywhere of the *gran seco,* a great drought that had

[8] "Journal of Researches," p. 377.

parched those regions desperately a few years before. It had lasted for many months, and thousands of cattle had died. Among the most severely affected were the *niata,* a breed of oxen much valued by the gauchos for the fancied charm of a short upper jaw. These pampered pets found it harder to crop the short, stiff herbage of the dry months, harder to tear the leaves from trees. For the first time Darwin grasped the idea of a struggle for existence. Plainly he saw how some small peculiarity of structure might, in time of dearth, lead to the extinction of one part of a species and to the dominance of another variety. Had the *gran seco* lasted for ten years, or had another drought followed soon, the *niata* would have become extinct.

He wrote home often, avoiding shop-talk as well as he could, and to Professor Henslow letting himself go on and on about what was filling his mind. This dealt mostly with geology and was rich in observation and reflection. Once he heard from his sisters that Professor Adam Sedgwick had called on his father and told the astonished doctor that his son should take a leading place among scientific men. "I could not," he declares,[4] "at the time understand how he could have learnt anything of my proceedings, but I heard (I believe afterwards) that Henslow had read some of the letters which I wrote to him before the Philosophical Society of Cambridge and had printed them for private distribution. My collection of fossil bones, which had been sent to Henslow, also excited considerable attention among palæontologists. After reading this letter, I clambered over the mountains of Ascencion with a bounding step, and made the volcanic rocks resound under my geological hammer. All this," he adds shamefacedly, "shows how ambitious I was."

A while before that it "had dawned on me that I might

[4] "Autobiography," p. 55.

perhaps write a book on the geology of the various countries visited, and this made me thrill with delight." Captain FitzRoy, also, had heard him read some of his journal, "and declared it would be worth publishing; so here was a second book in prospect!" . . . Darwin's literary and scientific careers were born together.

Upon his return to England, he paid only short visits to the family home in Shrewsbury, lodging mostly in London and Cambridge. The old plan of his entering the Church, never formally abandoned, gradually died a natural death. The old doctor remarked that the shape of his son's head was quite changed; and it is certain that the form of his character and intellect had changed, or at least that his character and intellect, unlicked, amorphous before the voyage, were now definitely formed and mature. It was no longer possible for him to be a minister or anything else except a research naturalist. His old love of hunting had gone; during the latter half of the voyage he had turned over to his servant the killing of the specimens he needed. His habits of gambling, wastefulness, and idleness were forgotten. His life was ruled henceforth by one desire—the desire to collect facts about nature and to devise explanations for them. Physically, too, he was changed. Perhaps it was the oft-repeated sea-sickness, perhaps the wretched food of the pampas, that made him an invalid for life. At any rate, his health was never satisfactory again. For years, his "wretched stomach" allowed him no single day free from pain. Much of his best work was done while he was actually sick.

Fortunately he had inherited an income large enough to eliminate the need of his undertaking any profession. He settled down to organize the huge masses of notes that he had made concerning phenomena observed during the voyage. The specimens that he collected were examined by various leading specialists, named (for many

belonged to species then unknown to science), and carefully classified. All this gave him several books to write and made him a man of remarkable eminence, considering that he was still well under thirty.

The first of this series to appear was the vaguely named "Journal and Remarks, 1832-1836." This was issued simply as the third volume of the official report [5] of the voyage. As such, its writing and publication were an essential formality, the justification to the Lords of the Admiralty of their appointment of a naturalist to the expedition. Actually it proved to be far more than a contribution to the archives. So great was Darwin's literary skill, enthusiasm, and a certain simplicity and freshness of approach, that this formal report has become a classic among books of travel. It was revised and republished twice,[6] and, under the apocryphal title of "The Voyage of the *Beagle*," [7] attained a fairly wide popularity. Long before the "Origin" appeared, Darwin was known, in circles not capable of familiarity with his more specialized work, as the brilliant young author of the "*Beagle*."

An account of the contents of this book has been given above and need not be repeated. It was in essence just what it is called—a journal of researches. Day by day, or as often as anything that interested him occurred, this young man, interested in many sides of life but especially so in the facts and laws of nature, noted his observations. This was done with great care at the time. After he reached England the notes were worked over thoroughly,

[5] "Narrative of the Surveying Voyages of Her Majesty's Ships *Adventure* and *Beagle* between the years 1826 and 1836, describing their examination of the Southern shores of South America, and the *Beagle's* circumnavigation of the globe. Vol. III, "Journal and Remarks," 1832-1836. By Charles Darwin. 8vo. London, 1839."

[6] "Journal of Researches in the Natural History and Geology of the countries visited during the voyage of H.M.S. *Beagle* round the world, under the command of Captain FitzRoy, R.N., 2d edition, corrected with additions." 8vo. London, 1845. (Colonial and Home Library.)

[7] "A Naturalist's Voyage. Journal of Researches, etc." 8vo. London, 1860.

rewritten in such style as to appeal to "the general reader," expanded, or simplified, or rounded out as the case might demand. The result was—as he once said of another's book [8]—"The best of all natural history journals which have ever been published." [9] The story is intensely interesting. Some of the experiences narrated involve hair-breadth escapes or touching and pathetic incidents. Descriptions of social customs and life in a land but little advanced out of barbarism, impressive pictures of the stupendous works of nature, touches of authentic wit—such as his picture of the Fuegian savages making all the valleys reëcho with the shouted word signifying "give me . . . "—flashes of noble indignation against the slave-system of which he saw so much, the manliness and shyness of the author's character, constantly cropping out despite chivalrous efforts to conceal it—all these would have made the book popular quite regardless of its scientific content. The two elements are fairly proportioned and alternate with a loose sort of regularity that seems like an intentional pattern: here an adventure, there a longish patch of geology, again some amusing sidelight on human nature, followed by a suggested explanation of some order in the discovery of fossils, and so on. One need not "skip the scientific parts," as he had advised his sister to do with Humboldt's "Personal Narrative," for many of these parts have a dignity and a vividness, and are infused with a sense of their vitality and direct significance to ourselves, that makes one want to read them. This is not equally true throughout, for the youthful naturalist indulges in some easily-forgiven parade of technical learning, but in innumerable instances it is the case. In fact, Darwin was so feebly the exhibitionist that the awkwardest passages in his book are those in which he seeks to depict his own feelings. This sentimental feature, the most staple one in many journals, diaries, and

[8] Thomas Belt, "The Naturalist in Nicaragua," Murray, 1874.
[9] F. Darwin, "Life and Letters of Charles Darwin," Vol. II, p. 366.

accounts of travel, has no place in a naturalist's journal, as indeed the power to create it had no part in Darwin's mind. For example, his strictly objective account of an earthquake is impressive and moving in the mere magnitude of the effects described; but one must smile at the uncomfortable clumsiness of his confession of the strange feeling of insecurity which is experienced on beholding the oldest and most permanent objects suddenly grown changeable.

If one should come to the reading of the "Journal of Researches" from some of Darwin's more mature books, it would probably seem rather stilted and showy in comparison. Never was there a simpler, homelier, less pretentious soul, yet even he wore more of an air in youth than he did after maturity had brought balance. But this is not really a fair approach. One should compare his first work, not with that of his prime nor with the work of his later contemporaries, but with that of his predecessors. His grandfather, or Sir Humphry Davy,[10] or Waterton, surnamed "the Wanderer," [11] or his own beloved Humboldt show more clearly the taste for an extravagance of dignity that was bred by the age then dying. Compared with any of them, Darwin wrote from the first with admirably unaffected, simple clarity. His subject in this rambling narrative of travels was naturally more popular than the subjects of his later books, but the style of his writing was rather less so. One who views literature as an art is happy to note this; it shows the craftsman becoming a master through practice.

Yet this point should not be too heavily weighted. The "Journal of Researches" is a fascinating book, and even its style is charming. The stiffness remarked is largely due to his using a self-consciously "elegant" vocabulary, and even

[10] "Consolations in Travel; or, the Last Days of a Philosopher."

[11] Charles Waterton, "Wanderings in South America, the Northwest of the United States, and the Antilles, in the years 1812, 1816, 1820, and 1824" (1825). For both of these see Part IV, Chapter XXII, below.

this fault grows less noticeable as the story proceeds. In power to describe an object or a scene so that it can be visualized and its immanence felt, in the use of helpful figures of speech and of geometrical diagrams (in words, of course) to make positions and directions more real, in ability to call scattered facts, diverse items of knowledge out of the vasty deep, to align them, all in their proper places, so that the reader has been won over to the conclusion which they imply long before that conclusion has ever been asserted, in a certain loosely dramatic rhythm according to which his very exposition proceeds, in the likableness of the author's personality, always sensed just below the surface of his writing, in all these qualities the great Darwin is present in this book. Above all, he possesses, like Homer and Chaucer, Shakespeare and the unknown poet of "Beowulf," a freshness or originality of mental attitude that transmutes any subject touched, however stale and dust-covered it may have been, into a new discovery. "'Tis like the morning of the world," and he, the first man, is seeing everything for the first time. Every object is full of interest and significance and rouses a fitting enthusiasm in the writer. But this enthusiasm is so inherent in the thing observed, so truly blended with the idea being explained, so free from any taint of having been whipped up by the author in himself, that the reader catches it too. Behold! he also is walking in a tropical wonderland, where the sensuous majesty of every impression is not delusive because it leads us toward an understanding of the reality that all thinking men long for.

Meanwhile the more technical sections of his report were being prepared with the coöperation of a staff of the most eminent specialists in England, who studied the specimens that Darwin had brought home, wrote "diagnoses" or detailed anatomical descriptions, named them, and classified them on the basis of their "affinities" to

animals already known. Richard Owen worked over the fossil mammalia, and the recent mammalia, birds, fish, and reptiles, were treated by Waterhouse, Gould, Jenyns, and Bell in the order named. The entire series,[12] in five volumes richly illustrated, was "published with the approval of the Lords Commissioners of Her Majesty's Treasury" who advanced a grant of £1000 to make the work possible, and was "edited and superintended by Charles Darwin." He also wrote the introductions, whose object is to explain the place of the animals named in their natural environment.

These are works of reference and therefore not rich in the sort of material for which we are looking. Furthermore, the greater part of each volume is the work of some other pen than Darwin's. However it is significant to note how much more interesting (to one not an anatomist) are his introductions than the rest of the work. And it is noteworthy that the other men engaged in the task of classifying the specimens, none of them then evolutionists, were conscious of the weaknesses of the established system. Owen, who was staggering somehow toward his own theory of "derivation," does not surprise us with his talk of the affinity of Toxodon "to the *Rodentia, Edentata,* and *Herbivorous Cetacea,*"[13] but it is arresting to come upon this bit in Leonard Jenyns' account of the fish, "There is an equal difficulty felt by every naturalist at the present day, in distinguishing species from varieties."

The geological works growing out of the voyage were three, published as three parts of "The Geology of the Voyage of H.M.S. *Beagle,*" with the "approval of the Lords Commissioners" but without scientific aid. First

[12] "Zoölogy of the Voyage of H.M.S. *Beagle* edited and superintended by Charles Darwin," Part I, 1840, Part II, 1839, Part III, 1841, Part IV, 1842, Part V, 1843.

[13] Roughly: rats, ant-bears, and whales!

came "The Structure and Distribution of Coral Reefs" (1842), a small book containing what for a time was known to geologists as "the Darwinian theory." This theory, based on the facts that coral reefs are composed of *living* polyps only *near the top* and that polyps cannot live at any considerable depth, concludes that the sea-bottom has been gradually subsiding during the entire period of the growth of a reef. Thus the living polyps have always been at or near the surface, the petrified masses which now form a mere base having lived on top before the bottom sank. Darwin divides coral structures into three classes and shows how his explanation applies equally to each of the three. He cites many facts to prove that there has been a general subsidence in those areas in which reefs are common, that, in other regions where there are no reefs, the sea-bottom has not settled.

Owing to its somewhat limited scope and its remoteness from our own affairs, this book has never won a very wide public. However, it might be read with pleasure by many who are not hydrographers, zoölogists, nor geologists. It lacks the grand sweep and movement of the "Journal," but it is no less vivid and intelligible. In fact, like the other technical studies based upon the voyage, it is in part an expanded, elaborate, documented retelling of what was informally sketched in the earlier work. Some passages are identical, word for word, in the two books, and some of the woodcuts are quite the same. Darwin, unlike Shakespeare, seems to have felt no qualms about repeating himself. In structure, this treatise is far more closely knit and coherent than the rambling "Journal." Its presentation is strictly inductive. There are four chapters of fact—descriptions of the types of reefs, descriptions of individual reefs and atolls, observations as to their growth and the conditions needed

for it—before he comes out, in the fifth chapter, with his own theory of their formation. This is odd, for we have the author's own testimony [14] that "no other work of mine was begun in so deductive a spirit as this, for the whole theory was thought out on the west coast of South America, before I had seen a true coral reef." However, we must not be prejudiced by such a beginning, for he continues: "I had therefore only to verify and extend my views by a careful examination of living reefs." That "only" is significant. A neat recapitulation rounds out and closes the book. The style throughout is precise yet vivid, clear, and cool, becoming technical only at long intervals—an excellently serviceable style for a work of science.

The second part of "The Geology of the Voyage of H.M.S. *Beagle*" was published in 1844. Its full title is "Geological Observations on the Volcanic Islands, Visited During the Voyage of H.M.S. *Beagle,* Together with Some Brief Notices on the Geology of Australia and the Cape of Good Hope." This book, like its predecessor, largely repeats and develops the observations of the "Journal." Although Darwin had his own theory of the distribution of volcanic islands—to wit,[15] that "they are generally arranged either in single, double, or triple rows, in lines which are frequently curved in a slight degree"—the book is not written chiefly to prove or explain that theory. It lacks the unity and order which a brief in argument must maintain. In short it is simply another journal, with the non-geological parts left out. This was a book which he could show his professors but not his sisters. More than in most of his works words of technical character abound, though well salted with simpler ones, and here and there one lights upon a brief personal touch or some characteristic flash that brightens whole strata of details. The influence of Lyell and his uniformitarian

[14] "Autobiography," p. 58. [15] "Geological Observations," p. 140*ff.*

doctrine is palpable and would be evident even if it were not acknowledged by citations.

It was not until 1846, just ten years after the return of the *Beagle,* that the last work directly growing out of the voyage saw the light. That was the "Geological Observations on the Parts of South America Visited during the Voyage of H.M.S. *Beagle.*" Much had occurred in those ten years. Working over and over his notes, examining and helping to classify his specimens, Darwin came to think more and more of one idea. The notion that species might be, not mystically, not metaphorically, but actually and physically akin had struck him while he was in South America and among the Galapagos Islands. Studying his observations at leisure made this idea clearer and stronger; the published "Journal" suggests it more emphatically than he had felt it earlier. Before reaching the work on "South America," he had begun collecting facts on species and recording them in his notebooks, he had devised the hypothesis of natural selection and named it, and he had written two essays, first a short sketch and later a treatise of volume size. All this was to him bare preliminary work, almost secret, and naturally he had never published anything on this subject. However, he cannot prevent some traces of his views from creeping into his book. It is this new and vitalizing interest that accounts, at least in part, for the greater appeal of "South America" as compared with the "Volcanic Islands."

The subject was a more interesting one anyway, for it necessarily dealt with life, and life, even when extinct and prehistoric, has an attraction for the mind. The author had found the remains of Indian art at a place now eighty-five feet above sea-level yet apparently a beach when it was inhabited by man. He tells most interestingly of his discoveries of fossil beasts and draws conclusions as to their affinities. He explains the formation and probable history of the pampas and Patagonia,

all with the aid of visual appeal and the personal touch.[16]

There is more plan as well as more purpose in this book. Not being in a position to build it upon a theory, he yet avoids the loose stringing together of the journal form, by arranging the chapters "according to the age of the deposits," beginning with the more recent layers at the top and gradually digging downward to the older and deeper ones. An especially significant section is that in which he combats the old idea that extinct animals were destroyed by some great catastrophe.[17] Says he, "We ought not properly to feel more surprised at a species becoming extinct than at one being rare, and yet we are accustomed to view the rarity of any particular species as an ordinary event, not requiring any extraordinary agency." He seems to be preparing to say that species, like individuals, may die a natural death; perhaps, like individuals, they may be naturally born from others "as an ordinary event, not requiring any extraordinary agency." From his work but surely more from the record of what he chose to call his idleness, we can see how, bit by bit, the dominating purpose of his life had been taking hold of him.

Now at length his *Beagle* tasks were finished. Ten years after the ship made port in Falmouth harbor, fifteen after the voyage began, his duty to the Queen, whose treasury sustained the expedition, and to Humboldt, who unconsciously inspired his part in it, had been done. It had been done well and amply. Henceforth Darwin might go freely about his own work, infinitely the richer for the experience and no longer a bounden slave to its obligations.

[16] More maps would be desirable. [17] "South America," p. 361.

CHAPTER XIII

SPECIES BECOME AN OBSESSION

In the meanwhile several important events had taken place in Darwin's life. In July 1837, less than a year after returning to England, he opened his first notebook for the collection of facts bearing on the origin of species. "I worked," he states,[1] "on true Baconian principles, and without any theory collected facts on a wholesale scale, more especially with respect to domesticated productions, by printed enquiries, by conversation with skilful breeders and gardeners, and by extensive reading. . . . I soon perceived that selection was the keystone of man's success in making useful races of animals and plants. But how selection could be applied to organisms living in a state of nature remained for some time a mystery to me.

"In October 1838, that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement 'Malthus on Population,' and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved and unfavorable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work." . . . "The Origin of Species" was published twenty-one years later!

Thomas Robert Malthus,* whose work Darwin read for amusement, had the distinction of suggesting the idea of

[1] "Autobiography," "Life and Letters," p. 68. * (1766-1834.)

natural selection both to Darwin and to Wallace, the two devisers of the same theory. He was an Anglican minister of philosophical tastes. He would have been known as a sociologist, save that in his day, before the advent of Spencer or even of Comte, sociology was unknown. His "Essay on the Principle of Population," issued in 1798, was the first attempt at an explanation of many very troublesome problems. He held that the population of any region tends to increase by *geometrical progression*—that is, roughly, by multiplication—while the food-supply tends to increase by the much slower *arithmetical progression*—the addition of definite increments. Sooner or later famine must result; some people must become poor and degraded; vice, crime, social conflict, misery, and war are the inevitable outcome. To avoid such degeneration the population should be kept from increasing or should be permitted to grow only gradually. Good churchman as he was, Malthus suggested late marriage and great continence of life as the best means of curbing increase in population. He could not foresee modern methods of artificial birth-control as an aid to loose morals any more than he could have anticipated his work leading to a theory that might make miraculous creation logically unnecessary. Yet, ironically, it is with these two matters that the name of Malthus is now associated.

How his principle fitted into the evolutionary scheme will be seen presently. . . . In 1839 Darwin married his cousin, Emma Wedgwood, whose sympathy and encouragement made his career possible, who later acted as nurse to him in illness and as a barrier to save his precious time and strength from the incursions of the outside world. They settled three years later in a vast, old house near the very tiny hamlet of Down.[3] Here in the midst

[3] Near Bromley, Kent; now usually spelled "Downe."

of an ample estate with plenty of space for gardens, greenhouse, laboratory, and the rest of a naturalist's equipment, in a rustic region silent enough for the habitual invalid yet so near to London that friends and colleagues might easily visit him, Charles Darwin spent the remaining forty years of his life. Here his great work was done, here his ten children were born, here he lived until his personality impressed itself upon the house and fields. Ill-health grew and fixed itself upon him. In 1842 he made his last geological tour; never again was he strong enough for such exertion. His life thereafter was an exceedingly quiet one. ("I have nothing to record during the rest of my life except the publication of my several books," he wrote in 1876.) He travelled rarely, going occasionally to a hydropathic institution for treatment or, rarely, to London for some important scientific gathering. His days were regulated minutely so as to allow the maximum of work that his health could stand. There were short alternating periods daily of writing (which he called "drudgery"), experimentation (which was his notion of "fun"), light exercise, and relaxation. During a great part of his life he could not work for more than three hours a day. Accurate and methodical habits and a firm desire to achieve helped him make the most of every moment. He himself indexed all the books he read so that he might find useful information without trouble even after years had gone by. Every pertinent fact he ran across was instantly recorded and filed away for later use. Thus he was constantly working at more than one investigation, carrying the several lines of inquiry along side by side.

Apart from a number of papers [8] read before scientific societies, his next work to appear was a series of four

[8] e. g. "On the Formation of Mould." read Nov. 1, 1837. Geol. Soc, Trans., 1840. Interesting as a fore-runner of "Formation of Vegetable Mould through the Action of Earthworms," 1881.

monographs on the barnacles.[4] This eight-year task—five in the writing—grew out of an attempt "to have described only a single abnormal individual *Cirripede* from the shores of South America." It absorbed him so thoroughly that his little son supposed that "to do one's barnacles" was the normal activity of an adult. He was aided by the British Museum as well as by many individuals and given the authorization of two leading learned societies. All this effort resulted in the production of a large and rather useful catalogue of the various genera and species of one sub-class of invertebrate animals.

This is certainly Darwin's most technical book. The species are listed and described, each "diagnosis" beginning with a short summary in Latin and proceeding in a form serviceable to anatomists, liberally supplied with technicalities. The subject had been confused and obscure; he managed to clear it up considerably, to bring some uniformity into the names used to describe certain structures, and to classify the entire congeries according to their affinities. He even discovered a few important points, such as the existence of the "complemental" males which mate in some species with the normal hermaphrodites. And he managed even here to use an occasional personal touch. Yet Darwin himself doubted whether the product were worth the trouble, though it brought what he never expected—the medal of the Royal Society. Says he, in a personal letter, "I have spent an almost ridiculous amount of labor on the subject, and certainly would never have undertaken it had I foreseen what a

[4] "A Monograph of the Fossil Lepadidæ; or Pedunculated Cirripedes of Great Britain," 1851 (Palæontographical Soc'y). The quotation is from Preface to Second Book, "A Monograph of the Sub-class Cirripedia, with figures of all the species. The Lepadidæ; or Pedunculated Cirripedes," 1851 (Ray Soc'y). "The Balanidæ (or Sesile Cuvripedes); the Verrucidæ," etc., 1854 (Ray Soc'y).

"A Monograph of the Fossil Balanidæ and Verrucidæ of Great Britain," 1854 (Palæontographical Soc'y).

job it was." Huxley has declared [5] that it most certainly was valuable: besides adding much to zoölogical knowledge, it gave its author some needed training in working with species, in sweating over their classification. His later theorizing about species would have been feebler had he not gone through this school of intensive work in "making," that is, in recognizing, describing, naming, and ordering the species of *Cirripedia*.

Now, in 1854, he was indeed free to devote his whole time and energy to a study of how the differences between species have come into being. It was almost twenty years since the idea had first come to him, seventeen since the first notebook had been opened, twelve since the first sketch of his theory had been set down on paper. The essay of 1842 [6] was plainly a mere sketch not meant to be published. It was written hastily in pencil, without title or chapter headings and in an exceedingly elliptical style. Some of the sentences are incomplete; some just allude to matters which they do not explain, as if meant only for the eye of one who understood what they referred to anyway. The whole essay covered thirty-five pages of manuscript—fifty-three as printed. For years it was lost and was discovered only by accident after his death.

Yet in spite of its absolute unimportance, the essay of 1842 really marks out the ground largely in the same manner as the "Origin of Species." Like the greater work, it begins with a discussion of the "creation" of special races or breeds of domestic animals by the selecting action of the breeders, who mate together those whom they prefer and whose qualities they wish to perpetuate in later generations. The idea of a "war of nature" [7] is next expounded, that war being shown to do the

[5] Quoted in Leonard Huxley's "Charles Darwin."

[6] See "The Foundations of 'the Origin of Species,' two essays written in 1842 and 1844 by Charles Darwin, edited by his son Francis Darwin," Cambridge, 1909.

[7] The phrase is admittedly taken from de Candolle, a French-Swiss botanist (1778-1841).

same work among wild animals that the breeder does among domestic ones. Wild animals do vary; "in the course of a thousand generations infinitesimally small differences must inevitably tell." The better will win, live, and have descendants; the less fitted will die out. This struggle supplies a kind of "natural selection"—and the true cause of the difference between species is explained. In attempting to show why fossils have not been discovered for each variety intermediate between two species, in other words, why there are "missing links" in the chain, he goes into the "imperfections of the geological record," just as he was to do later, showing that there must have been innumerable fossil forms which cannot possibly be discovered because they have been utterly destroyed. That he realized the connection of his doctrine with Lyell's is shown by the comment that "Lyell's views, so far as they go, are in *favour*, but they go so little."

The evidence of geographical distribution of organisms, known to him since the Galapagos days, is treated suggestively. There are interesting remarks on the affinity and classification of species. Every system of classification aims intentionally at being the natural one. Yet unless various species are physically related to one another, there can be no natural system of classification but one based on chance resemblances only. The horse looks something like the donkey; is there any sense in styling one *Equus caballus* and one *equus asinus*, if their likeness is merely accidental? But if they are blood cousins, the whole situation is changed. "Naturalists [8] cannot avoid these terms of relation and affinity though they use them metaphorically. If used in simple earnestness, the natural system ought to be a genealogical one."

The old "unity of type" idea, which Geoffroy Saint-Hilaire expounded, Cuvier flirted with, and Owen was

[8] "Foundations," p. 36.

to develop, comes in for comment.[9] . . . "This wonderful fact of hand, hoof, wing, paddle, and claw being the same, is at once explicable on the principle of some parent-forms . . . becoming through infinite number of small selections adapted to various conditions." The argument from embryology, well known to old Erasmus Darwin, is briefly advanced. The unborn human child at various times takes the forms of various lower orders. What is the meaning of this unless it be a "recapitulation" of the history of its ancestors? So, too, the possession of abortive or useless organs suggests a past when those organs were not useless. This is the last argument presented. It is followed by a summary and conclusion. The latter is a rather long, rhetorical peroration, charged with solemnity and wonder. The very words and phrases in which it is couched, as well as the arrangement of thought and the emotional tone that permeates it, were repeated substantially unchanged in the essay of 1844 and in every edition of the "Origin."

That hasty sketch, summarizing the results of five years' occasional study and reflection, was followed two years later by a much longer, fuller, and more carefully written essay.[10] This was produced entirely during the summer of 1844, no mean achievement considering its two hundred and thirty-one pages full of collected facts and pointed suggestions. Darwin regarded this essay as of some importance. He had it copied over "fairly" by a professional penman, bound, and put into a safe place. He also wrote his wife a letter of instruction, declaring it his "most solemn and last request," that in case of his sudden death she should devote £400 to its publication. A competent naturalist—preferably Lyell or Hooker—was to be employed, given all Darwin's personally indexed and annotated books, and set upon the task of editing

[9] In *"The Foundations of the Origin,"* pp. 39-9.
[10] *Ibid.* See note to p. 132.

the essay and making it fit for the combat which it was certain to meet. However, this was merely an emergency measure. If he lived, Darwin meant to experiment further, no matter how long it might take, to keep on piling up facts, and eventually to write the real book of which he dreamed—a book without weak spots or unsupported assertions, which would challenge attention and command the respect of the most learned anatomists. . . .

There never was a man who knew better how to bide his time, not weakly nor timorously hesitating too long, but knowing that to rush half armed into such a battle would be to make himself laughable and his labors vain. A contrast is illuminating. It was in that same year, 1844, that the brilliant Scotch publicist, Robert Chambers, launched his "Vestiges of the Natural History of Creation." That widely read book created as great a stir as Judge Lindsey's "Companionate Marriage" in our own time because it blurted out the anti-theological doctrine that man was descended from the ape and that all species had descended with modifications from a few aboriginal ones. It will be remembered how the "Vestiges" was dealt with—bullied by the critics, condemned by preachers, and laughed at by naturalists for its insufficient knowledge of the sciences. Its theory was the old one of Lamarck, refurbished and not proven. And here was Darwin, living with and by and for his doctrine, having now thought through all its main lines and experimented to prove many of its assertions, having set his matter down in writing, yet quite unwilling to give it to the public because it was not yet a perfect hypothesis. He had gone so far as to write a book—his second on the same subject—but he in no wise regarded his work as finished. He had merely made another preliminary sketch, an architectural blue-print, not a completed structure. Nevertheless, unlike the "pencil sketch" of two years earlier, the essay of 1844 is a well-rounded, well-written,

and rather complete book. Remember that if the author had died suddenly, it would have stood, with some editing, as the monument of his life's work. It shows all but one of the main lines of argument that were to be developed in the greater work, as well as a considerable abundance of illustration drawn from very various sources—his own experiments, things observed during the never-to-be forgotten voyage of the *Beagle,* and the fruits of extensive reading. His careful indexing of all books read, his filing of all facts, his painstaking research are evidenced in the fulness and variety of the essay.

Like its predecessor of 1842, the essay is divided into two parts, corresponding roughly to the presentation and the rebuttal of a debate. Part I has no general title, but its aim is to explain the theory that the species of plants and animals have been formed by descent with modification from preëxisting species, the governing influence being what he named "natural selection"—a figurative way of saying that creatures best fitted for life will live and that their descendants will be more like them than like the other, less successful, members of the old species. In this part there are three chapters. The first discusses the formation of breeds of domestic creatures and shows that selection by man is the determining factor in producing permanent types. The second chapter transfers the whole process to a state of nature, illustrating the great similarity of the natural competition for food, life, and reproduction to the conscious selection by man of types that he prefers. It compares domestic "races" with true species to the conclusion that the differences are not of kind but only of degree. The third chapter takes up the question of whether mental traits can have been evolved in the same manner and also discusses some of the difficulties which are thus raised.

Part II is definitely argumentative. Its title is "On the Evidence Favourable and Opposed to the View that

Species are Naturally Formed Races, Descended from Common Stocks." One of the most obvious, most usual arguments against the probability of evolution is drawn from the fact that there are so few forms or traces of forms intermediate between the known species. We do not find even the fossil remains of such half-way beings. In a thorough geological chapter, the answer, briefly touched on in the earlier sketch, is given fully: such fossils as have been discovered "do tend, the little way they go, to make good the series . . . according to the manner required by our theory," [11] but much has been destroyed and hurled into misleading confusion: [12] "Lyell has compared the geological series to a work of which only the few latter but not consecutive chapters have been preserved; and out of which, it may be added, very many leaves have been torn." Another chapter gives geological reasons for believing in the gradual, rather than the sudden, introduction and extinction of species, a vital point. The significance of geographical distribution is given a comprehensive treatment in a later chapter. Where there are impossible barriers, as on isolated islands, the fauna and flora are generally quite unique, as Darwin had seen so vividly in the Galapagos. On his theory, this is to be expected. So is the fact that kindred species of a genus are found closest together within the territory over which the genus ranges, whereas distant or dissimilar species live furthest apart, close to opposite borders of the region. A corresponding law was found to hold true in *time* as well as in space. Then, in a treatment of classification, the author overturns many of the older standards, concluding, as in the earlier sketch, that the natural system of grouping should form a family tree. He considered the embryonic history of a species a most important feature in tracing its relationships and showed why, under the theory of natural selection, this must be so. The "reca-

[11] "Foundations," p. 137. [12] *Ibid.*, p. 141.

pitulation," by each unborn individual of the physiological history of its parents and of other forms of life, had been known to the earlier Darwin, to Lamarck, and to Buffon. These men had regarded it as in some mystical way a proof—a sort of revelation—that this form had evolved from those others. Natural selection *showed how* it had happened, removed the mystery, and made of recapitulation indeed a strong reason favoring evolution; variations appearing in mature life, and not helpful in the struggle until maturity, tend to appear in the offspring likewise at that time of life, not earlier.

"Abortive" or "rudimentary" organs can be explained in a similar manner. These parts, such as the teeth of whales, which are destined never to emerge from the gum, were stumbling-blocks to all the older naturalists, but, by disuse through generations, they might readily—"if natural selection is a true force—be explained. Yet [13] if this theory be rejected, these facts remain quite inexplicable; without [14] indeed we rank as an explanation such loose metaphors as de Candolle's in which the kingdom of nature is compared to a well-covered table, and the abortive organs are considered as put in for the sake of symmetry!"

The tenth chapter, an excellent brief summary of all the rest, also psychoanalyzes our reluctance to accept the idea of change. Here the author at last declares clearly that [15] "On this theory, therefore, all the organisms *yet discovered* are descendants of probably less than ten parent-forms."

The concluding passage is largely the same which we have met in the sketch and are to meet again at the end of every edition of the "Origin." It is a peroration in the grand style, of which the last flourish follows: [16]

[13] "Foundations," p. 238.
[14] The solecism is typical. See Chapter XVII below.
[15] "Foundations," p. 252.
[16] *Ibid.*, p. 254.

"There is a [simple] grandeur in this view of life with its several powers of growth, reproduction, and of sensation, having been originally breathed into matter under a few forms, perhaps into only one, and that whilst this planet has gone cycling onwards according to the fixed laws of gravity and whilst land and water have gone on replacing each other—that from so simple an origin, through the selection of infinitesimal varieties, endless forms most beautiful and most wonderful have been evolved."

Darwin's insistence that this essay was never "intended for publication" is almost pathetic. With a little polishing, it might well have done and would have been the best exposition of the subject so far written.[17] It stated all the main lines of his argument save one—the advantage of divergence. His "Autobiography" and his paper for the Linnean Society both show that he thought this a serious omission, but his son, Sir Francis Darwin, disagrees in these words: [18] "I have found it difficult to recognize the absence of any definite statement of the principle of divergence as a flaw in the essay. Descent with modification implies divergence, and we become so habituated to a belief in descent, and therefore in divergence, that we do not notice the absence of proof that divergence is in itself an advantage." The one real omission may thus be no serious fault at all. Besides such completeness in the argument, this essay is moderately rich in detail and in references to specific significant fact. The general plan is much the same as that upon which the "Origin" is formed, except that the Essay preserves a division into two parts, which, though abandoned in the "Origin," sometimes seems to be implied in it.

In style the essay differs decidedly from the later work. It is far less compact. The facts it contains are

[17] "Life and Letters," p. 377. Dorsey even declares the same to be true of the earlier sketch. See "Evolution of Charles Darwin."

[18] "Life and Letters," p. 377.

fewer, and there is none of the sense of painful condensation that can be recognized in the "Origin." That book was planned as a mere abstract of something far vaster; it is, long and complete and elaborate though it be, psychologically a mere abbreviated outline of what was to follow. Accordingly, references and substantiating documentation are regretfully omitted, and there is a pressed, clipped hardness of style such as befits an abridgment. Not so the essay. In 1844 the author was able to say all he knew or had reasoned out or hoped to investigate, could say it all fully, breezily, a little rhetorically in spots, with no haunting fear of taking up too much space, and could still finish within two hundred and fifty pages. "It [19] has not all the force and conciseness of the "Origin," but it has a certain freshness which gives it a character of its own. There is an air of freedom, as if the author were letting himself go rather than applying the curb." Of course, it is definitely more finished than the crude, earlier sketch as well as far fuller. Its style shows some of the grace that might have been expected of the author of the "Journal of Researches," and the theorizing is satisfyingly ballasted with facts.

[19] See "Foundations." Introd. by Francis Darwin.

CHAPTER XIV

THE GREAT BOOK—FRIENDS AND A RIVAL

THE "species question" was never dropped, but for years nothing more was written except entries in the notebooks and letters to personal friends. Of these there were many, and they grew more numerous with the years, but there were three men in particular who helped enormously by aid, encouragement, and enlightening argument, though without agreeing that Darwin's ideas were right.

To these three men, above all others, he looked for help, to them he confided his then wild beliefs, from them he begged seeds of rare or peculiar plants, skeletons or even living birds or animals of especially needed breeds, upon them he shyly, hesitatingly, yet unmistakably piled special assignments to observe phenomena typical of their own opportunities. One of these men was his cousin, W. Darwin Fox, the same who long before had introduced him to science by way of beetle-hunting. Fox had grown into what Darwin himself might well have become had the plans of his father been realized: a country preacher whose "Sunday duties" interfered with, but could never cast out, the experimental gardening and breeding that really formed the core of his life. To him Darwin wrote, trying to explain what he meant by natural selection and how it differed from "any Lamarck nonsense of a *tendency to progression*" and "the slow willing of animals,"—trying and not succeeding. But when he asked for any plant that grew in Fox's Derbyshire or for a spoonful of caked mud from the foot of a wild partridge, so that he could see how many seeds were

thus transported and could test their germinating power, Fox proved a friend indeed.

Another of his letter-writing friends was Sir Charles Lyell, who had won his own fight for a uniformitarian doctrine in geology and was regarded as one of the two or three greatest masters of the subject. Lyell was a safe Liberal in views; he had overturned the history of the earth but, after considering the origin of species, had decided that geology did not prove evolution. Everywhere he was considered a stalwart tower of faith in the separate creation of species. His geological methods had started Darwin upon a career of overturning old notions, and the younger man affectionately addressed him as "my old master." With Lyell, Darwin had many a lengthy dispute by word of mouth and by letter. Always the older jokingly feared lest he might yet be "*perverted*" to the other's heresies. He pointed out objections to the theory of natural selection, and Darwin systematically recorded them, experimented, and found answers. In all their dealings, Lyell proved a loyal friend, genuine scientist, and honorable gentleman. Never—at least not yet—convinced, he aided the researches and reasonings of his disciple and opponent in every way. At a crucial moment his loyalty was to be decisive and all important.

The third friend was Sir Joseph Dalton Hooker,* who succeeded his father as director of the Royal Botanical Gardens at Kew, a few miles up the Thames, to the southwest of London. Dr. Hooker was younger than Darwin; he had devoured Darwin's "Journal of Researches" upon the eve of his departure to explore the botanical Antarctic, and it had been to him very much what Lyell's "Principles of Geology" was to Darwin in the early stages of his explorations. The three men thus formed a chain of succession, but they were also equals, each respected by the others as a specialist wise in his own kind of learning.

* (1817-1911.)

Hooker was primarily a botanist, and it was in botany that Darwin most keenly felt his own weakness and lack of systematic training. Hooker helped mightily. His own writings, "Antarctic Flora," "Flora of New Zealand," [1] "Australian Flora" (1859-60), were works of reference, enormously serviceable as store-houses of facts but scarcely the sort of thing that one might read for pleasure. Hooker had wonderful opportunities to aid Darwin's researches; in the Royal Gardens, he would find plants and seeds that were required or the space and equipment to carry on experiments that were beyond the means of even a prosperous country gentleman. The two met often, usually at Down, and talked, discussed, argued as much as the semi-invalid's poor health allowed. Each came away from these interviews convinced that he was the gainer by far, that he "had carried away more than he could stagger under."

Yet no one of Darwin's three intimates was convinced of the correctness of his theory. Their objections gave him new ideas, new directions for his study. His wide knowledge, his ingenuity in research, his depth and soundness in theorizing won their respect if not their assent, and all were eager to sponsor his conclusions.

Long before Darwin himself felt ready to give his conclusions to the world, Lyell and Hooker began separately urging him to publish. Something ought to be done with the vast materials that he had been accumulating; such monumental labors should not be permitted to go to waste. The facts gathered were valuable whether or no the conclusions should prove likewise. So said the thrifty Lyell. And Lyell feared lest someone forestall his friend. At last, pushed and pulled, Darwin started to do what

[1] Part of "The Botany of the Antarctic Voyage of H.M.S. *Erebus* and *Terror* in the years 1839-1843, under the command of Captain Sir James Ross," 1853.
"Handbook of the New Zealand Flora; a Systematic Description of the Native Plants of New Zealand," 1864.

he himself greatly disliked: to write a very brief abstract of his future great work for possible publication in advance of the years and years which must intervene before the great work could be ready. Scruples kept him from making it an article for "any periodical or journal," as, he wrote, "I positively will *not* expose myself to an Editor or a Council, allowing a publication for which they might be abused. If I publish anything, it must be a *very thin* and little volume, giving a sketch of my views" . . . though "it is really dreadfully unphilosophical. . . ." He began work upon a sample chapter, sent it to Hooker, dropped it altogether.

In the meanwhile another doughty lieutenant was enlisted. Both Darwin and Hooker felt that the key to the origin of species was geographical distribution, or the relation between various species and the lands or waters that they live in. Between the two, most of the types of living things on the earth could well be mapped, for Darwin knew the animals, especially those of South America, while Hooker knew the plants, especially those of India, Australia, and the Antarctic. Both knew Europe and its productions. Yet neither had ever visited the vast and important region of North America. Darwin took thought: he had once been introduced to Professor Asa Gray * of Harvard, an eminent botanist who knew the plants of the United States like a second Solomon. He was a wise and brave man, sincerely religious too, respected by all. To him Darwin wrote, recalling and actually creating a friendship, pressing him into service as a reporter on North American species, their variation, affinities, and modifications.

Gray was glad to answer, and the scientific correspondence led to a delightful friendship. Eventually Darwin confided to Gray his great secret—of which he had once said, "it is like confessing a murder"—"But [2] as an honest

* (1810-1888.)

[2] "Life and Letters," p. 437.

man, I must tell you that I have come to the heterodox conclusion that there are no such things as independently created species—that species are only strongly marked varieties. I know that this will make you despise me."

But he had underestimated his own intelligence or his friend's tolerance. Instead of despising him, Gray asked for more enlightenment. Eventually, in 1857, he wrote a longish letter outlining the main points of his theory. Though written for the eyes of but one man, this letter is a model of significant conciseness. Its five pages—except for the characteristic hesitations and apologies,—"I always expect my views to be received with contempt . . . "—are keen and hard as a steel blade, solid, full of matter, stripped of empty adornment, yet "beautiful as a well-handled tool." This letter contained one topic that is not even mentioned in the earlier essays. It devoted a paragraph to the *principle of divergence:* "the varying offspring from each species will try (only a few will succeed) to seize on so many and as diverse places in the economy of nature as possible. Each new variety or species when formed will generally take the place of, and so exterminate its less well-fitted parent." Thus there are *missing links* today in the evolutionary chain; we see only the surviving species which have diverged from forms that now are dead, so that what we see is not a perfect chain. We see the twigs and leaves of a great family-tree of life, but not the trunk nor the main branches, "the flourishing twigs destroying the less vigorous—the dead and lost branches rudely representing extinct genera and families."

In the meanwhile, protesting yet yielding to his friends, he had set to work on the book. His letters of the period show that it was designed upon heroic proportions. He did not mean "to publish for several years." There were still many experiments to be tried, conclusions to be retested, facts and rumors to be verified, masses of mate-

(ABOVE) A CORNER OF THE GARDEN AT DOWN, SHOWING THE GREEN-HOUSE AND LABORATORY AND THE BEGINNING OF THE "SAND WALK."
(BELOW) DOWN HOUSE AS SEEN FROM THE FIELDS.

rial to be sifted. It was a thrilling, terrifying experience. . . . "I am working very hard at my book, perhaps too hard. It will be very big, and I am become most deeply interested in the way facts fall into groups. I am like Crœsus overwhelmed with my riches in facts, and I mean to make my book as perfect as ever I can. I shall not go to press at soonest for a couple of years. . . ."

In that letter,[3] written on February 8, 1855, to his Cousin Fox, one recognizes the joyous travail of the creative artist. For nearly two years the Great Book had been taking shape. The long harrowing and cultivating of the soil was being justified by a promise of harvest. Yet that fruition must not be hastened, even by the fear —on which Lyell harped—of being forestalled. He needed time and strength and patience and more time "to make the book as perfect" as ever he could. A couple of years more, after the twenty that had gone, would be the soonest that he could go to press.

The Great Book—judging from correspondence, for it, alas! is not in existence—was modelled after the two earlier essays. Like them, it began with a study of variation of domestic animals and the creation of new races, or breeds, through man's selection, suggested that if there existed a selecting power in Nature that power could form the different species. Like those essays, too, it must have shown how keen and desperate is the struggle for life among wild living creatures, how efficiently a natural kind of selection works to destroy individuals or races that are less favorably adapted than others to struggle successfully. Similarly he planned a section devoted to answering objections—which he had been busily accumulating—a study of the question as to why intermediate species are not found in fossilized form.

The book grew and grew. He experimented and wrote. To test the struggle for existence in a vivid man-

[3] "Life and Letters," p. 467.

ner, he cleared a space in his garden about one yard square, noted every seedling that cut the soil;—there were 357 in all and "no [4] less than 295 were destroyed, chiefly by slugs and insects." He had bad days too: "The [5] work has been turning out badly for me this morning, and I am sick at heart; and oh! how I do hate species and varieties." And again [6] " . . . talking yesterday with Lubbock, he has pointed out to me the grossest blunder which I have made in principle, and which entails two or three weeks' lost work; and I am at a dead-lock. . . . I am the most miserable, bemuddled, stupid dog in all England, and am ready to cry with vexation at my blindness and presumption." Sometimes his illness grew unbearable and he had to quit work for a course of "hydropathy," the only means of relief. It was during one of these intervals that he wrote his wife: "Yesterday,[7] after writing to you, I strolled a little beyond the glade for an hour and a half, and enjoyed myself—the fresh yet dark green of the grand Scotch firs,[8] the brown of the catkins of the old birches, with their white stems, and a fringe of distant green from the larches made an excessively pretty view. At last I fell fast asleep on the grass, and awoke with a chorus of birds singing around me, and squirrels running up the trees, and some woodpeckers laughing, and it was as pleasant and rural a scene as ever I saw, and I did not care one penny how any of the beasts or birds had been formed." Yet he did care many a penny and many a pound how the birds and beasts had been formed. Believing "that all these absurd views [9] arise from no one having . . . approached the subject on the side of variation under

[4] "Origin," p. 83. See also "Life and Letters," pp. 449, 457.
[5] "Life and Letters," p. 460.
[6] Letter to Hooker, July 14 (1857). "Life and Letters," p. 461.
[7] "Life and Letters," p. 471.
[8] The Scotch firs crop up in the "Origin," p. 87.
[9] That is, the views of Lamarck, Chambers, etc. Letter to Hooker, 1844, "Life and Letters," p. 389.

domestication and having studied all that is known about domestication," he went so far as to form some species himself. Suspecting that the several breeds of domestic pigeons—the pouter with its curiously pompous, distended chest, the fantail, that miniature peacock, the tumbler with its strange habit of turning somersaults—were all descended from a single ancestral pigeon, he set to work upon them. He got the humble, primitive rock-pigeon and bred it. He joined two pigeon fanciers' clubs (and never got over his astonishment at their accepting a novice like himself). He subscribed to the fanciers' journals, picked up all the gossip he could, corresponded with noblemen who had well-stocked dovecotes, hob-nobbed with illiterate poultry-men, listened and learned. At length, by careful breeding and selection, *he himself made pouters and fantails; he transformed the simple rock-pigeon into various breeds quite different in appearance and habits from one another and from their common progenitor.* It was sharing the privilege of creation.

For a long time to come, however, his creation must be literary. The Great Book must be written, and he slaved away at it. Sometimes a new difficulty, a new objection to the theory would arise in his mind, and for a time all would be at a standstill. He would ply his friends, or any naturalist who might know, with questions, would devise a solution and rush back into the battle of pen and ink. Like a Spartan, he refused to accept the convenient theories of other men—such as Edward Forbes, who made "continents as easily as a cook makes pancakes"—unless the idea would stand all sorts of tests and jibe well with all facts. Thus he wrote to Hooker: [10] "There never was such a predicament as mine: here you continental extensionists would remove enormous difficulties opposed to me, and yet I cannot honestly admit the doctrine, and must therefore say so." Imagining con-

[10] July 30, 1856. "Life and Letters," p. 438.

tinents raised out of the sea long enough to allow animals to migrate or seeds to be carried from one point to another, then supposing the intervening portions sunk, might explain the similarity of species on islands far from each other. But he could not honestly admit the doctrine and must therefore say so. He had to think out other means of distribution, then try them to see if they would work. He floated seeds in sea-water for days, weeks, months, then planted them, and some of them grew! He calculated how far they might have been carried by ocean currents in the time. He gathered facts on the migration of birds, and on the insects, eggs of fresh-water shell-fish, and seeds of plants which they carry and may therefore transplant. He studied the migration of plants from north to south during the glacial ages, that terror-stricken flight before a chill enemy. He was fertile in invention, cautious in accepting explanations.

The Great Book kept getting bigger and bigger. Sample chapters were sent to Hooker, and Darwin was always tremendously encouraged by his friend's praise, humble about his own writing. "You [11] have undertaken a horrid job in so very kindly offering to read it, and I thank you warmly. I have just corrected the copy, and am disappointed in finding how tough and obscure it is; but I cannot make it clearer, and at present I loathe the very sight of it. The style, of course, requires further correction, and if published I must try, but as yet see not how, to make it clearer."

By the spring of 1858, he had finished the first draft of about ten chapters. The Great Book would be at least three volumes, and as yet little more than half had been written. Five years more might pass before it would be published—just a quarter of a century after the central idea of the theory had first been conceived. But that would not be too long; elephants are the slowest breeding

[11] May 6 (1858). "Life and Letters," p. 465.

of all animals. And then something shocking, something unforeseen though tragically, obviously foreseeable, happened—and the Great Book was turned into a laughable impossibility.

Far away, on the other side of the world, an English traveller was unlucky enough to suffer from an attack of malarial fever, and while lying idle in his hammock, unable to do any more difficult work, he amused himself by thinking out the theory of natural selection. Lyell's words had "come true with a vengeance"; Darwin *was forestalled!*

The god—or devil—who had thus thrust himself out of the machine was Alfred Russel Wallace,[12] a younger, stronger, more energetic man than Darwin, a more daring and supple naturalist, a shrewder debater, more skilful writer, quicker thinker—all things, in short, but a more honest, patient worker. He had gone out to the islands of the Malay Archipelago to study the insects and the birds of that region. He had been struck with the slight differences between the inhabitants of the various islands, just as Darwin had been struck thirty years before during his short visit to the similar archipelago of the Galapagos. He had written several admittedly brilliant "communications" which had been read before associations of naturalists in London. What interested Wallace especially was the vast and hitherto neglected question of the geographical distribution of animals. One of his papers on this subject, "On the Law that Has Regulated the Introduction of New Species," [13] had intrigued the interest of Lyell, who commended it to Darwin. The latter, with characteristic kindness, wrote Wallace to tell the glad tidings of what praise his paper had received, and continued,[14] "Though agreeing with you on your conclusions

[12] See Chapter XIX below. (1823-1913.)
[13] Published in the *Annals and Mag. of Nat. Hist.*, 1855.
[14] Dec. 1857, "Life and Letters," pp. 465-7. [12] See below.

in that paper, I believe I go much further than you; but it is too long a subject to enter on my speculative notions." Mention of the species work was made, with the habitual comment, "I do not suppose I shall publish under a couple of years."

All in all it seems likely that Wallace had no clear idea of what Darwin was trying to do, save that it dealt with species, their classification, and distribution. So, when he had written out the theory that had passed through his mind during that feverish week in Ternate of the Celebes, what more natural than that he should send it to the older colleague for criticism and comment?

So one fine day, the postmaster at Down delivered to the invalid resident of huge Down House a letter and an essay that had been weeks in coming from the Malay islands. The letter asked him, casually enough but trustingly, to read the essay and to pass it on to Lyell. What a dilemma Darwin was in! To what temptation did it not lay him open! He might have thrust the sheaf of papers into the grate; Wallace must wait for months before he could expect an answer; he would never know but the package might have been lost in the Indian Ocean or off the Gold Coast. The product of a delirium would have vanished as swiftly as the disease.

But Darwin, for all he is quoted today as the arch-enemy of Victorianism, was at heart a thorough English gentleman of the Victorian school. What he felt can be read between the lines of his letters, but what he did was correct, honorable, and courteous—and self-effacing. He sent the manuscript, as Wallace asked, to Lyell, and wrote, wryly, one supposes: [15] "I never saw a more striking coincidence; if Wallace had my MS. sketch written out in 1842, he could not have made a better short abstract! Even his terms now stand as heads of my chapters. Please return me the MS., which he does not say he

[15] June 18 [1858]. "Life and Letters," p. 473.

wishes me to publish, but I shall, of course, at once write and offer to send to any journal. So all my originality, whatever it may amount to, will be smashed, though my book, if it will ever have any value, will not be deteriorated; as all the labour consists in the application of the theory.

"I hope you will approve of Wallace's sketch, that I may tell him what you say."

A week later, after hearing from Lyell, he again wrote setting forth both sides of the case with exemplary fairness and many apologies: how he had written two sketches years before, and a letter to Asa Gray about a year back, "so that I could most truly say and prove that I take nothing from Wallace. I should be extremely glad now to publish a sketch of my general views in about a dozen pages or so; but I cannot persuade myself that I can do so honourably. . . . I would far rather burn my whole book, than that he or any other man should think that I had behaved in a paltry spirit. . . . It seems hard on me that I should be thus compelled to lose my priority of many years' standing, but I cannot feel at all sure that this alters the justice of the case. P.S. I have always thought you would make a first-rate Lord Chancellor; and I now appeal to you as a Lord Chancellor."

The letters and the essay were forwarded to Hooker so that Darwin might have the opinion of his "two best and kindest friends." They, like his Uncle Jos. when the *Beagle* post was offered and declined, did not propose to let him quietly eliminate himself. They were quite at one in acting like friends indeed, yet with eminent fairness to the outsider as well. Together they planned a convenient compromise which would give Wallace full credit for his separate originality yet would announce to the world what Darwin had accomplished as well as display a sample of his work.

Men engaged in research take the keenest interest in

the meetings of learned associations and academies at which papers are read and discussed, both authors and critics being as technical or as combative as they may choose to be. The excitement of such gatherings was often too much for Darwin's health, and he went but rarely to meetings. Of these associations, he found the Linnean Society most congenial and often sent papers to be read there, even when he could not be present in the flesh. The Fellows, like the great Linnæus whose library formed the nucleus of their own, had an especial interest in the recognition and classification of species. Appropriately, then, it was before the Linnean Society that, sponsored by Sir Charles Lyell, master geologist, and Sir Joseph Dalton Hooker, Overseer of the Royal Botanical Gardens at Kew, a joint paper by Messrs. Darwin and Wallace was communicated. This took place on the evening of July 1, 1858, less than two weeks after the receipt of the fateful message. Speed was urgent; another paper, programmed for the occasion, had to be postponed. The two authors were absent—Wallace on his remote island, necessarily; Darwin, whom considerations of good taste might have withheld, was ill and shaken; an epidemic of scarlet fever, raging in Down, had claimed seven children, including his own Annie, a sweet child after the school of Little Nell. Two of his other children were sick, and the nurses who came to tend them fell sick also. It might have proven a time of triumph, but happiness was missing.

The joint paper[16] takes up no more than seventeen pages of print and makes no pretense at unity or completeness. It consists of several separate sections beginning with a letter signed by Lyell and Hooker which gives a history of the various essays and extracts that follow. These "taken in the order of their dates, consist of:

[16] In "Journal of Proceedings of Linnean Society," Vol. III, Zoölogy, pp. 45-62. "On the Tendency of Species to Form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection."

1. Extracts from a MS. work on Species (Note. Never intended for publication, and therefore not written with care, C.D.) which was sketched in 1839 [17] and copied in 1844, when the copy was read by Dr. Hooker, and its contents afterward communicated to Sir Charles Lyell. 2. An abstract of a private letter addressed to Professor Asa Gray, of Boston, U.S., in October 1857. 3. An essay by Mr. Wallace, entitled "On the Tendency of Varieties to Depart indefinitely from the Original Type," written at Ternate, February, 1858." The sponsors declared that it was their insistence which led Darwin to include his own work. "We are not solely considering the relative claims to priority of himself and his friend, but the interests of science generally; for we feel it to be desirable that views founded on a wide deduction from facts, and matured by years of reflection, should constitute at once a goal from which others may start, and that, while the scientific world is waiting the appearance of Mr. Darwin's complete work, some of the leading results of his labours, as well as those of his able correspondent, should together be laid before the public."

Darwin's contribution consisted of old material which need not be rediscussed here in detail. The extracts from his 1844 essay were perhaps the most original and characteristic sections: Part I, Chapter II, "On the Variation of Organic Beings in a State of Nature; on the Natural Means of Selection; on the Comparison of Domestic Races and True Species," a total of four pages. Any essay as brief as this must be highly theoretical, and so this is. Yet it is strikingly written, some of the cruder spots of the old secret essay having been polished down for the occasion. There is but little mere technicality in it, and even the large expanse of theory is well ballasted with illustration. It deals with the struggle for existence,

[17] This date, given in the Linnean Journal, seems to be an erroneous reference to the sketch of 1842. See Introduction to "Foundations of the Origin."

the Malthusian calculation of increase beyond any possible supply of food, the infinitely numerous variations in living forms, "the better *chance* of surviving" for those with fortunate variations, the selecting action of nature in killing the unfit and thus raising the next generation only from the fit. All is told with rare clarity, like the instruction offered by a gifted teacher.

However, as that old essay said nothing about the "principle of divergence," the letter to Asa Gray had to be included. This very brief message, model of conciseness, is even more complete than the other extract. It includes a short treatment of artificial breeding by selection, and shows, by an ingenious metaphor, how similar natural selection is. By treating divergence, it goes on to classification; no topic could be more Linnean.

Wallace's essay, nine pages in length, shows an uncanny likeness to Darwin's in its subject-matter, its approach to the subject, its general attitude, and even in its wording; yet the style and the underlying personality, for which style is a form-fitting garment, must be recognized as glaringly at odds with Darwin's. Right from the opening flourish to the clinching summary, the author is arguing. He is an aggressive man, thoroughly convinced himself and ready with a flood of facts and reasons to overwhelm anyone who might be so absurd as to disagree. If Lyell might have made a first-rate Lord Chancellor, Wallace could have been an equally capable whip for His Majesty's Opposition in the House.

Everything he says burns with intense logic. It is so logical that one cannot answer, yet it rankles, for one senses the voice of the professional debater. The sentences flow smoothly, and the construction is aimed skilfully at clearness. Technical terminology is quite absent, yet there is a judicious parading of special learning. A little pomposity and some artificial rhetoric can be felt; one imagines the sick man lying in his hammock and

making sweeping, noble gestures as he thought out some of the rolling periods for this eloquent oration.

It is a more hypothetical treatment of the question than Darwin's, though that also was too abbreviated for detailed facts. Psychologically it is far better, for it begins with the viewpoint of the average half-educated person, and argues its way through to the conclusion which the writer desires to enforce. People suppose, says he, that varieties always return to the original types, that essentially all species are permanent. But in nature there are permanent varieties—incipient new species. Then he turns to the struggle for existence. He cites the rapid increase of birds, one pair in fifteen years having ten million descendants, which enormous increase must lead to competition. He assumes that they vary, some becoming weaker and some better fitted to thrive.[18] "Now, let some alteration of physical conditions occur in the district—a long period of drought, a destruction of vegetation by locusts, the irruption of some new carnivorous animal seeking 'pastures new'—any change in fact tending to render existence more difficult to the species in question." The inferior variety would die out first, then the parent species. "The superior variety would then alone remain, and on a return to favourable circumstances would rapidly increase in numbers and occupy the place of the extinct species and variety." It "could never return to the original form; for that form is an inferior one, and could never compete with it for existence." He views this as a "doctrine of chances," which, because of the vast time and the almost infinite numbers involved, becomes "strictly accurate." Unlike Darwin, he minimizes the significance of variation among domesticated animals, for their lives are unnatural wherefore selection among them is on a false basis. Without naming it, he suggests the survival value of "mimicry,"

[18] "Linnean Journal," p. 58.

or protective imitative coloring, of which there will be more said later. There is no doubt in Wallace's mind as to the superiority of natural selection over the Lamarckian hypothesis of evolution by use and disuse and the slow willing of animals. "Neither did the giraffe acquire its long neck by desiring to reach the foliage of the more lofty shrubs, and constantly stretching its neck for the purpose, but because any varieties which occurred among its antetypes with a longer neck than usual *at once secured a fresh range of pasture over the same ground as their shorter-necked companions, and on the first scarcity of food were thereby enabled to outlive them.*"

The essay ends with a summary, such as a lawyer must use in driving home the main points of his case; it shows also why Wallace chose the particular title which he did choose. "We believe we have now shown that there is a tendency in nature to the continued progression of certain classes of *varieties* further and further from the original type—a progression to which there appears no reason to assign any definite limits."

The first reaction to this remarkable joint essay was an utter and stupefied silence. At the meeting Lyell and Hooker, "the greatest Geologist and Botanist in England," used their personal influence to insure a considerate hearing. Hooker has described it thus: [19] "The interest excited was intense, but the subject was too novel and too ominous for the old school to enter the lists before armouring. After the meeting it was talked over with bated breath: Lyell's approval, and perhaps in a small way mine, as his lieutenant in the affair, rather overawed the Fellows, who would otherwise have flown out against the doctrine."

One interesting outcome had best be told in the words of George Bentham,[20] who figures most largely in it—an outstanding botanist, at times collaborator with

[19] "Life and Letters," p. 482. [20] "Life and Letters," II, p. 88.

Hooker. "On the day that his celebrated paper was read at the Linnean Society, July 1st, 1858, a long paper of mine was set down for reading, in which, in commenting on the British Flora, I had collected a number of observations and facts illustrating what I then believed to be a fixity of species. . . . Most fortunately my paper had to give way to Mr. Darwin's and when once that was read, I felt bound to defer mine for reconsideration; I began to entertain doubts on the subject, and on the appearance of the 'Origin of Species,' I was forced however reluctantly, to give up my long-cherished convictions, the results of much labour and study, and I cancelled all that part of my paper which urged original fixity." The joint essay, furthermore, made a convert of Hooker, who, be it remembered, had undertaken to be its godfather at a time when he did not approve its conclusions. But the notion of natural selection—or his championing of it—"acted as a purgative on (his) bowels of immutability." Within a few months he had begun to write an introductory essay to the vast catalogue, "The Flora of Tasmania," [21] in which he "goes the whole length" says Darwin,[22] who adds,[23] "To my judgment it is by far the grandest and most interesting essay on subjects of the nature discussed I have ever read." In accounting for the character of the plants in Australia and Tasmania, Hooker reversed the position he had taken in his earlier work [24] to advance the opposite hypothesis that species are derivative and mutable, " . . . to adopt such a theory as may best harmonize with the facts."

His power as a writer is not constant. There is some tendency to the typical vices of scientific writers: formality, prolixity, bareness, self-consciousness, abstraction.

[21] With G. Bentham, Part III of "Botany of the Antarctic Voyage of H.M.S. *Erebus* and *Terror*." (1859-1860.)
[22] "Life and Letters," p. 517.
[23] "Life and Letters," p. 51, Vol. II.
[24] "Flora of New Zealand."

Yet he avoids too great technicality, and his treatment is broad, and inspiring in its breadth; there are many vivid passages, and there is no affectation nor pedantic triviality. Above all, he was applying newer and truer views in a significant way, and the significance makes his essay vital and daring.

Others of the Old Guard were meanwhile armoring. Owen's lecture [25] "On the Classification of the Mammalia" has been discussed above. It was delivered during the spring of 1859 and shows an unmistakable consciousness that transformism had once again become a living issue. Owen, however, did not at all understand the idea of natural selection nor did he recognize the difference between the old hypotheses of Lamarck and this unprecedented explanation.

[25] See Chapter X above.

CHAPTER XV

ARMS CLASH ON PARNASSUS

WITHIN a few days after the fateful meeting, Darwin's mind was made up. A battle was coming; the gage had been flung down. His Great Book would take too long for the necessities of warfare. On the field, as Schiller says, the present rules. His forces must be mobilized more quickly. Should he hastily revise the essay of 1844 and rush into print with it? That idea was soon dropped. He resolved to prepare another abstract, fuller than any yet written but much briefer than the book he had planned. By September the preparation was well under way. In October he wrote,[1] "I am working most steadily at my Abstract, but it grows to inordinate length; yet fully to make my view clear (and never giving briefly more than a fact or two, and slurring over difficulties), I cannot make it shorter. It will yet take me three or four months; so slow do I work, though never idle." But it kept on growing at the rate of a chapter every three months. Not until almost a year later could he say, "The neck of my work, thank God, is broken."

The correspondence with his friends continued. There were the usual difficulties thought of, urgent questions and experiments without which he dared not rest, the usual interruptions due to poor health, the courses of hydropathy, the usual fear lest he appear too presumptuous, the usual—more than usual—struggles with the mysteries of literary style. "Thank you," he writes to Hooker,[2] "for telling me about obscurity of style. But on my life

[1] "Life and Letters," p. 493. [2] May 11, 1859, *Ibid.*, p. 512.

no nigger with lash over him could have worked harder at clearness than I have done. But the very difficulty to me leads to the probability that I fail." and [3] again, "I have fairly to blacken them [the proofs] and fasten slips of paper on, so miserable have I found the style. You say you dreamt that my book was *entertaining;* that dream is pretty well over with me, and I begin to fear that the public will find it intolerably dry and perplexing."

The manuscript had meanwhile been accepted, through Lyell's mediation, by John Murray, foremost of London publishers. Never did a writer more generously urge upon a publisher the latter's prerogative of refusing the book, nor would many authors have addressed their publishers [4] thus: "I find the style incredibly bad, and most difficult to make clear and smooth. . . . How I can have written so badly is quite inconceivable." He insisted on paying the £72/8s that the printers demanded for changes in the proof; Murray insisted on paying it himself, and Darwin never got over his amazement and gratitude at the publisher's generosity.

Murray did not like the term "natural selection," but Darwin would not give it up, and it stayed. The publisher, furthermore, objected to calling a big book of about six hundred pages an abstract, so at last Darwin, though still cherishing a mental reservation and the hope of one day completing his Great Book, sighed and renamed it "The Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life." When the last, terrible proofs had been corrected late in October, he went away to his favorite resort in Ilkley and freed his mind of the incubus that had been driving it so long. . . . The first edition was published on November 24, 1859, the entire stock of 1250 copies being sold on the day of publication. A second edition was called for. The book was hastily corrected and re-

[3] "Life and Letters," p. 515. [4] *Ibid.*, p. 464.

vised, so that, on January 7th, the public was given another edition, this time of 3000 copies.

In these days of vast book sales—even in scientific and philosophical fields—there may appear to be nothing extraordinary in these figures. But in the good old times the reading public was far smaller than today and far less bent upon improving its mind by the discipline of reading. A popular novel would see its thirty or forty thousand copies, but a learned treatise—never. And "The Origin of Species," despite its author's laboring at clearness, was by no means a popularized version, predigested spoon-meat for the unequipped babe. Its sudden vogue and lasting popularity were astonishing to all, but to no one more than to its author.

He had not dared to hope that it would succeed widely, preferring the good opinion of a few competent judges even to large sales. "If [5] some four or five *good* men came round nearly to our view, I shall not fear ultimate success. I long to learn what Huxley thinks." The good men that he had in mind were mostly his old familiars: Hooker, already a convert, Lyell not yet *per*-verted but intensely interested and showing signs of being "in ever so slight a degree staggered," Henslow, his old teacher, Asa Gray, and Huxley.

The last of these, whose name was later to be coupled with Darwin's like those of a second Damon and Pythias, had not appeared much or notably in Darwin's life before that time. He was a rather younger man, very busy professionally—at his varied duties as "government professor"—and very busy by temperament as well, primarily interested, too, in the much narrower field of physiology. But at this time, Darwin, so alone in his evolutionary views, began to wish for Huxley's opinion. A year or two earlier, Huxley, brashly and with no knowledge of Darwin's long study of the species question, had blurted

[5] "Life and Letters," Vol. II, p. 20.

out to the older man that species must be permanent and had not grasped the gentle irony of the other's reply, "that such was not altogether his view." What would Professor Huxley say now?

An advance copy of the book was sent to him, and he replied with a heartening message on the day before publication; "Nothing," he declared,[5a] "can be better than the tone of the book. As for your doctrine, I am prepared to go to the stake, if requisite, in support of Chapter IX." Huxley, far better than Darwin himself, instantly foresaw the struggle, not always on scientific grounds, that must be expected. He continued, "I trust you will not allow yourself to be in any way disgusted or annoyed by the considerable abuse and misrepresentation which, unless I greatly mistake, is in store for you. Depend upon it you have earned the lasting gratitude of all thoughtful men. And as to the curs which will bark and yelp, you must recollect that some of your friends, at any rate, are endowed with an amount of combativeness which (though you have often and justly rebuked it) may stand you in good stead.

"I am sharpening up my claws and beak in readiness."

What a trumpet-blast that was and how powerful an ally had been gained! Darwin replied, "Like a good Catholic who has received extreme unction, I can now sing 'nunc dimittis.' " It was not long before Huxley's "claws and beak" were called into vigorous play. Within the month a lucky chance made it possible for him to review the "Origin" for the London *Times*. The article was unsigned, and indeed the opening paragraphs were the work of the staff reviewer, a Mr. Lucas. But with the third paragraph and the question, "What are species?" the masterly touch of Huxley comes into evidence. The article discusses the whole species question, deriding Lamarck and the "Vestiges" with typical Huxleyan scorn

[5a] See "Life and Letters," p. 26.

and growing ever more forceful as it proceeds. Only toward the end is Darwin mentioned; he is praised for his popular "Voyage of the *Beagle*" and his authoritative "Monograph of the Cirripedia." There is an outline—in two paragraphs!—of the "Origin," which book is lauded vastly. Yet Huxley admits in all candor that most of those capable of knowing attribute species to special creations. In style the review shows qualities that were destined to be called into action frequently: a fierce readiness for combat, glossed over by an almost preternatural suavity, a blunt homeliness of phrase and an elaborate rhetorical apparatus, keen sarcasm, frankness in admitting the weakness of his own case, vindictiveness in showing his strength, and a knack of popular expression. An example of the last is his comparing the recapitulation by the unborn embryo of simpler forms of life with a group of people leaving church; all go down the aisle together, some to part at the door, some at the rectory, some at the corner, some only in the next parish.

Darwin was delighted with the review. He knew well what great influence it was bound to have upon the wide circle of newspaper readers. The book was becoming a popular success—exactly what its author had never been so foolish as to expect. Not long after—on February 10, 1860—Huxley delivered a lecture "On Species and Races and their Origin" at the Royal Institution. This was an event of no trivial importance. To prepare for it, he went through much of the manuscript of the still unpublished Great Book,[6] and Darwin procured charts and skeletons for illustration. The lecture was less successful than the review. Huxley was beguiled into eloquent digressions, only to leave out essentials later for lack of time. The *Edinburgh Review* for April contained a bitterly cruel attack upon Darwin's theory, coupling with it a denunciation of "the audacity of the dispenser

[6] "More Letters of Charles Darwin," pp. 140-7.

of the hour's intellectual amusement" at the Royal Institution.

That review was published under carefully guarded anonymity; but a manuscript copy of it was found among the papers of Sir Richard Owen after his death. It was probably his work. Step by step he developed into the arch-antagonist of evolution, claiming that he had discovered it first, as derivation, and that it wasn't true anyway. It seems to have been Owen also who inspired Bishop Wilberforce's similar review in the *Quarterly*. His later writings and his personal dealings tended toward the same end.

Meanwhile, however, friends were the first to speak. Watson a very considerable botanist, wrote,[7] "You are the greatest revolutionist in natural history of this century, if not of all centuries." Lyell at last yielded and definitely planned to admit the theory of evolution in the next edition of his now classic "Manual of Geology" [8]—even in his "Antiquity of Man," on which he had begun to work. W. B. Carpenter, the physiologist, wrote a review for the *National* and a critique for the *Edinburgh* in which the *odium theologicum* was met. In America, Asa Gray entered the battle on the same side, though with some reservations, and after writing a review, which Darwin called "admirable . . . by far the best," arranged for an American edition to be published. Professor Bronn, deeply learned German authority, volunteered to supervise a German translation of the "Origin." Others, such as Jenyns and Henslow, both clergymen-botanists, indicated their partial acquiescence. And Kingsley, whose Christianity was muscular, came out flat-footed for evolution. "I have gradually learnt to see," says Kingsley,[9] that it is just as noble a conception of the Deity, to believe that He created primal forms

[7] "Life and Letters," Vol. II, p. 21.
[8] A condensed form of the "Principles of Geology."
[9] "Life and Letters," Vol. II, p. 82.

capable of self-development into all forms needful *pro tempore* and *pro loco,* as to believe that He required a fresh act of intervention to supply the *lacunas* which He Himself had made. I question whether the former be not the loftier thought." Later, with more time to polish, he phrased the idea thus: "We always knew that our God was wise enough to make all things; now we have learned that He was wise enough to make all things make themselves."

In writing the "Origin" Darwin had decided not to discuss the human race, as "that might bring in religion"; yet not to dissemble his views entirely, he declared in the conclusion [10] that "much light will be thrown on the origin of man and his history." Even without this gentlemanly declaration, the implications of a purely naturalistic explanation of life were bound to be felt by many persons as a shock to their faith. Many were not able so easily as Kingsley to find a place for any such belief. One of the earlier attacks, and for personal reasons one of the most painful, came from Adam Sedgwick, Darwin's instructor in geology, who had once predicted that the youth would rank among the foremost men of science. The letter was a personal and not unfriendly one; yet it had this to say: "I have read your book with more pain than pleasure. Parts of it I admired greatly, parts I laughed at till my sides were almost sore; other parts I read with absolute sorrow, because I think them utterly false and grievously mischievous. You have *deserted*—after a start in that tram-road of all solid physical truth —the true method of induction, and started us in machinery as wild, I think, as Bishop Wilkins's locomotive that was to sail with us to the moon. . . . There is a moral or metaphysical part of nature as well as a physical. A man who denies this is deep in the mire of folly." After much more to the same purpose, Professor Sedgwick subscribed

[10] "Origin," Vol. II, p. 304.

himself, "your true-hearted old friend." Later Sedgwick repeated these hostile views before the Cambridge Philosophical Society and in a notice published in the *Spectator*.[11]

Dr. Whewell, another of the grand old men of science, wrote less bitterly and without a sense of shock, yet he would not assent to the new views and for years refused to allow a copy of the "Origin of Species" to be added to the library of Trinity College, Cambridge, over which he presided. The *Saturday Review* [12] attacked the geological portions of the book, sneering at the great periods of time required by this theory. Wollaston, reviewing for the *Annals and Magazine of Natural History*, demands to know "Who is this Nature . . . ? Is she aught but a pestilent abstraction, like dust cast in our eyes to obscure the workings of an Intelligent First Cause of all?"

It will be noticed that most of those who demurred from the evolutionary view stood at least partly on theological ground. This has been the fate of Darwinism ever since, complicated by the further fact that some of the Darwinians, such as Haeckel, have chosen to proclaim themselves atheists. Nothing was further from Darwin's own intention. He had no clear ideas on religion himself, recognizing that it was quite outside his field. He was not interested in religion but in natural phenomena. He never aimed to obscure the workings of an Intelligent First Cause, as the philosophical convention of the time called God, but to illuminate and clarify such secondary causes as fell within his ken.

The most remarkable hostile review appeared [13] in the *Quarterly*, that hotbed and classic nursery of hostile reviews ever since the day of Byron and Keats. Unsigned, of course, it seems [14] to have been written by Samuel

[11] See "More Letters," pp. 149, 150, 151.
[12] Dec. 24, 1859. See note, "Life and Letters," Vol. II, p. 54.
[13] *Quarterly Review*, July 1860, Vol. 108, pp. 225-264.
[14] See Huxley's "On the Reception of the 'Origin of Species'," "Life and Letters," p. 536.

Wilberforce, Bishop of Oxford, prompted here and there by Sir Richard Owen.[15] This review begins softly with praise for the author's "characteristic excellences" of style, "perspicuous language . . . picturesque combinations . . . colours of fancy and the lights of imagination," with tributes also for his character. But, little by little, the silken paw is retracted, laying bare the sharp talons beneath. Gradually the bishop begins to disagree and finally grows strident, intolerant, and unmannerly in his disagreement. His arguments are old ones, mainly negative: that "it is not fair to argue from the variations of the plastic nature" of domestic animals to that of wild ones. . . . "We affirm positively that no single *fact* tending even in that direction is brought forward. . . ." Embalmed animals found in Egyptian tombs show that some species were the same 4000 years ago as today. And so on.

A few samples of his tone may be of interest. "We find it difficult to find a theory fuller of assumptions"; it is the "merest hypothesis supported by the most unbounded assumptions"; it shows "how far the love of a theory may seduce even a first-rate naturalist"; the author is a "flighty person" trying "to prop up his utterly rotten fabric of guess and speculation" in a mode that is called "dishonourable to Natural Science." There is a shrewd—and largely justified—comparison of Darwin's habits to thought and very mannerisms of expression with those of his grandfather, whose poorly based speculations were so ingeniously parodied in the *Anti-Jacobin.* Of course Owen and Murchison are mentioned with awe and their very un-Darwinian views cited in refutation. Then Lyell is named for his adherence to creation despite "similar faults," and it is hoped "that with his help . . . this flimsy speculation may be as completely put down as was . . . its twin though less instructed brother, the 'Vestiges of Creation.'" Ironically at that moment, the per-

[15] See Dorsey's "Evolution of Charles Darwin."

verted Lyell was preparing a public acknowledgment of his own new adherence to natural selection.

The book, about which so many people were disputing, is a short, thick volume of fifteen chapters,[16] not purporting to be anything more than an abstract of a bigger book to follow. So much has been said about its contents that little need be added here on that head. In general it followed the plan of the early essay and of the earlier sketch, with these exceptions: it was at the same time far fuller and far more condensed; it treated the principle of divergence, assimilating that phase of the question completely; it no longer preserved the division into two formal parts—one presenting the theory and a second arguing for it—but it still implied some such organization.

The presentation could not well have been more inductive. The book begins with that part of the question that is nearest to us, variation under domestication. Here, by a multitude of examples, the author shows how new varieties are *made* by men. Variation under nature is next studied and shown to follow lines essentially similar. The third chapter treats of the struggle for existence; and its consequence, natural selection, which acts just as does the artificial selection of a breeder, is discussed in the fourth. This is followed by a treatment of the laws of variation—of which admittedly little is known; yet it is interesting and must once have been illuminating to see variation itself ranged according to laws. Two chapters of difficulties to the theory follow, with such answers as suit the various questions. Then there are special chapters for especially complicated problems: the origin of instincts (he was not ready to discuss the origin of mind), and hybridism, or what happens when members of separate species interbreed. Chapter X, "On the Imperfection of the Geological Record," was one of those proclamations which Huxley said came like a flash of light;

[16] The first edition had fourteen, for it lacked a chapter of rebuttal.

once it had been uttered it was self-evident, and people wondered why no one had thought of it before. It attempts [17] to answer the natural question that, if all species have been constantly changing, "why, then, is not every geological formation and every stratum full of such intermediate links? The explanation lies, as I believe, in the extreme imperfection of the geological record." This is followed naturally by studies of the succession of organic beings in time and of their distribution in space; that is, geographically. Chapter XIV takes up the various loose ends: [18] mutual affinities, classification, morphology, embryology, rudimentary organs—those meaningless survivals of former usefulness which, like silent letters still spelled in modern words, point to a more vital past. The book ends, as does each chapter, with a recapitulation and summary; and, of course, Darwin's favorite flourish is there—"endless forms most beautiful and most wonderful have been and are being evolved."

When trying to account for the striking philosophic success of this book, Darwin said,[19] "The success of the 'Origin' may, I think, be attributed in large part to my having long before written two condensed sketches, and to my having finally abstracted a much larger manuscript, which was itself an abstract. By this means I was enabled to select the more striking facts and conclusions. I had, also, during many years, followed a golden rule, namely, that whenever a published fact, a new observation or thought came across me, which was opposed to my general results, to make a memorandum of it without fail and at once; for I had found by experience that such facts and thoughts were far more apt to escape from the memory than favorable ones. Owing to

[17] "Origin," p. 413.

[18] Not in the first edition, in which the final chapter (elsewhere the XVth) is numbered XIV. He planned to "introduce a new chapter in answer to miscellaneous objections."

[19] Autobiography, "Life and Letters," p. 70.

this habit, very few objections were raised against my views which I had not at least noticed and attempted to answer. . . . Another element in the success of the book was its moderate size; and this I owe to the appearance of Mr. Wallace's essay. . . . I gained much by my delay in publishing from about 1839, when the theory was conceived, to 1859; and I lost nothing by it."

Now in this long personal revelation there are two points of especial significance: the thought of the book was fully matured by the long period during which the question was being closely and alertly studied, and the literary form of the book benefited greatly by the various recastings, expansions, revisions, and recondensations through which it was forced. Both points are vital. It is a subtle question—perhaps a useless one—which is more so. As to the first point, we have only to compare the "Origin" with any of its predecessors to see its immeasurable superiority. Buffon has only a few pages devoted to evolution as such, and he assumes that climate causes it, apparently without even seeing the necessity of proving that assumption. Lamarck's facts are drawn from more various fields, but they cannot compare in number, variety, or genuineness with Darwin's, and the supposed explanations are simply invented terms to name imagined conceptions which might later perhaps be discovered to be real. And old Erasmus's "Zoönomia" is a book on many things of which evolution is only one. "Mr. Vestiges" was frankly an amateur and popularizer, whose very statements of facts he had taken over untested, and whose knowledge tottered more than once. In all there is a nervous and fallible haste which, compared with the majestic calm of the "Origin," is like radio jazz before the unresting rumble of Niagara. He had indeed lost nothing by the delay. The earlier books were pitted with loop-holes, but scarcely an objection could be raised against Darwin's which he had not anticipated.

And so it is usual to point to the fulness, the factual wealth of the "Origin" as the cause of its great strength. Without denying or minimizing the importance of this, one must grant that it is but half the story and that the other half reads like a contradiction of it. After all, the "Origin" was but one-fourth or one-fifth what the uncompleted Great Book would have been, "and very few would have had the patience to read it." The author never wearied of apologizing, especially to other naturalists, for its deficiency in facts, instances, and references. "Remember it is only an Abstract "became for him a sort of "*Delendum est Carthago.*" The book itself is peppered with reminders of this, such as: [20] "To treat this subject properly, a long catalogue of dry facts ought to be given; but these I shall reserve for a future work."

There is, furthermore, something in the way the book was written, in its structure and style and in the personality that can be seen through its network of observation and reasoning, something that made the "Origin" an immediate popular success and has kept it permanently a popular favorite. All sorts of persons who are not scientists have read it and still read it, and they do not rank it among the wasted products of the pen of Professor Dryasdust. Casual readers often think it easy and pleasant reading. This is in curious contrast with the opinion of competent naturalists. Thus Hooker writes: [21] "It is the hardest book to read, to full profits, that I ever tried —it is so cram-full of matter and reasoning. I am all the more glad that you have published in this form, for the three volumes, unprefaced by this, would have choked any naturalist of the nineteenth century." However, there is no paradox. A naturalist, aiming to read "to *full profits,*" goes at such a book as this quite differently from the general reader, who is more than pleased

[20] "Origin," p. 51.
[21] "Life and Letters," Vol. II, p. 35.

if only he can grasp the general idea. The former studies every fact and finds a book so rich in facts as this hard reading, while the latter sails along, taking the facts largely on faith and an air of probability, thankful that the reasoning is clear and the language vivid. Even Hooker adds, "it is also extremely clear as far as I have gone, but very hard to fully appreciate." This sums up the matter. The book spoke equally to both sorts of readers; fully for the specialist, interestingly for the layman.

Now, how does the book read? What is the secret of Darwin's rare success with the pen? We know from his letters that he hoped vaguely for popular success, but again despaired of ever attaining it, and that he valued the adherence of even three capable judges more highly than the plaudits of millions; that he slaved away at clearness; that he actually grew angry over the confused state of technical nomenclature; that in his youth he had been an admirer of Shakespeare and Milton. In short, we know that literary quality was not something quite outside his consciousness, as it is to some scientists. Like Lyell, he said, "I must write what will be read," and strove to make his writing readable.

First of all, there is the structure or general plan of the book as a whole. That form was the outcome of the several recastings which had chipped and filed off whatever was extraneous, rounded and filled in what was scanty, smoothed over what was raw. The "Origin" has been called "one long argument": As such its structure is essentially logical, proceeding inductively from facts to inferences, from groups of inferences to general conclusions, through a rebuttal of anticipated objections to an ultimate establishment of the far-flung general conclusion, in toto. It is, as Lyell called it,[22] a splendid case of close reasoning, and long substantial argument."

[22] "Life and Letters," Vol. II, p. 2.

Yet its general structure is psychological as well as logical. It avoids the barren, logic-mongering pedantry that Spencer, for example, so often verged upon. The presentation is not only what reason requires but what is most natural to the imagination. It begins with that class of facts which most people are most familiar with—the changes brought about by man upon the animals that he has tamed. After the power of human selection has been shown, after the struggle for existence has been indicated, follows the vivid metaphor of Nature selecting the fit, rejecting the unfit. Segments of fact—quoted from the most delightfully varied sources such as English farmers, personal friends, his own experiences, Chinese encyclopedias, mediæval laws—alternate with stretches of theory to form a work of regular pattern like an "egg-and-dart" frieze or a sonata. Consciously or unconsciously, this author designed his book to accommodate the taste of the reader.

Another and more obvious structural device is the use of frequent summaries. Practically every chapter ends with one, as does the entire book also. In a work as expansive as this, some such "clincher" is well-nigh indispensable to aid the reader in holding the parts of the scheme together. The summary has a further advantage: some minds that may be shocked or bewildered by a novel theme, begin to feel at home in it when they have met several somewhat varied repetitions of what is essentially the same idea.

The style of the "Origin" is no less fitted to its purpose than is the structure. It is calm, undramatic, unemotional, sensible, as the style of a work of science and reason should normally be, and at the same time is, on the whole, simple and lucid. Many scientists stand so straight that they fall over backward; in avoiding an emotional style, they become crabbed, pompous, turgid, reeking with obscure technical pedantry. Not so Dar-

win; he uses a technical term when it is obviously a means of saving time and space, but not otherwise, and he never scruples to give an explanation or a visual illustration that will make some matter clearer, or to put an idea into normal human language rather than into the artificial codes of scientific convention. For instance, to convey an idea of what vast changes may have occurred in a million years, he declares [28] that "few of us . . . know what a million really means," and he suggests this method of forming an adequate conception: "take a narrow strip of paper, 83 feet 4 inches in length, and stretch it along the wall of a large hall; then mark off at one end the tenth of an inch. The tenth of an inch will represent one hundred years, and the entire strip a million years. But let it be borne in mind, in relation to the subject of this work, what a hundred years implies, represented as it is by a measure insignificant in a hall of the above dimensions. Several eminent breeders, during a single lifetime . . . have formed . . . a new sub-breed." Here is a device, one of many consciously employed so as to make one of the most customary abstractions significant to the reader.

Darwin seems to possess a freedom from self-consciousness so perfect that he can gossip quite casually about himself without appearing in the least obtrusive. This is one of his greatest assets as a writer. A story of personal discovery is far more interesting to the general reader than an abstract recital of facts and conclusions. Often it makes the writer appear conceited, or it intrudes an irrelevant barrier of human perverseness between reader and subject-matter. Not so with Darwin: his references to himself, his sons, his voyage in the *Beagle,* his friend Sir So and So or Professor This or That give at least one reader a sense of complete aptness. He does not talk about himself needlessly; he and his work are blended so

[28] "Origin," p. 420.

thoroughly that they cannot be separated—that is all. He does not parade his personality, but his work is suffused with it. By all evidence, internal as well as direct testimony, that personality was a delightful, charming, modest one. Its presence in the book makes the book likewise agreeable.

He had a real gift for making the most of his own experience. The "Origin" is rich in little things drawn together from everywhere; things seen in Patagonia or the Galapagos, traditional lore of Kentish herders or gardeners, personal experiments, and a vast body of reading and correspondence poured their cargoes of fact into the huge notebooks and portfolios and thence into his book. And each of these details had a certain identity or *real existence* in his mind, what might be called a soul of its own, so that he could write of it with a freshness and liveliness not usual in books intended for instruction. Too many professors are anatomists at heart; they cannot understand a thing until it has been killed and skeletonized. But to Darwin the whole world was alive and full of an early-morning freshness. Even when he touches the dry bones of some prehistoric fossil, suddenly we see the thing in its habit as it lived. Like a few of the most blessed of poets, Homer for instance, he writes as though he were the first man in the world and everything were new and full of interest.

Yet there is no falsification. In the "Origin," as he never ceased to regret, references are meagre, yet even here acknowledgment is made to his predecessors and other helpers. Even this does not destroy the sense of utter newness. It does, however, suggest one other of the great charms of Darwin's work—his complete honesty. In a book devoted to proving one side of a disputed question, we might expect a slurring over of the points favoring the other side or a vigorous attack upon such arguments as seem to contravene his doctrine. But one finds

only candid statements of both sides. Often the author confesses that he has no explanation to offer in some special case of doubt. Or he suggests that his entire theory might be overthrown by the discovery of a simple fact of a certain kind. This candor is actually an advantage in argument, both logically and psychologically. He is such a decent fellow that one wants to see him succeed. And again, when he confesses that he has a dearth of facts on a certain matter and then produces a fairly respectable array of them, opposition has been disarmed and is taken by surprise. It is interesting to read the hostile reviews of his work and to note how many of them concede his candor or even pay a tribute to it;[24] only fanatics, who bridled at the mere notion of evolution without reading the "Origin of Species," consistently attacked the man and his character.

There was, of course, much opposition, some of it important. One of the most stirring incidents in the early war over evolution came about in 1860 at the Oxford Meeting of the British Association for the Advancement of Science. This association meets annually, and the gathering is of vital importance to the whole nation. Scientists come from all quarters of the empire and from other lands to read their papers and display their collections. The public is not excluded; in fact, much of the speaking is influenced by the presence of an untrained audience. There is a Presidential Address, pronounced by some savant of towering eminence and quoted in hundreds of newspapers, an introduction by some important layman, and a sermon by a famous divine.[25] The devotees of special sciences segregate into small sections to

[24] e.g. See "Organic Evolution" by the Duke of Argyll and the review, above cited, in *Quarterly*.

[25] Thus at the Leeds meeting, Sept. 1927, Sir Arthur Keith (anthropologist) delivered the Presidential Address on "Darwinism Today," inaugurating a movement to preserve Downe House; the Duke of York opened the meeting, and Canon Barnes suggested a "ten-year scientific holiday."

hear and dispute fiercely over moot questions. The association, younger and scarcely so Olympian as the Royal Society, has somehow caught on to the technique of publicity and, for all its traditional ceremony, is full of life.

Now in July 1860 there was no more rousing question in men's minds than that of evolution. On the whole the world was opposed to it, yet a small, well-trained, and aggressive band had determined to uphold the new doctrine. Of these Huxley was the leader, and he journeyed to Oxford, his "beak and claws" sharpened and in readiness.[26] The Old Guard, too, planned to crush the dangerous notion without delay. Samuel Wilberforce, Bishop of Oxford, author of the critique in the *Quarterly Review,* was the most appropriate gladiator, and behind him hovered the shadowy outlines of the anatomist, Owen. As usual, Darwin himself was missing:[27] "How I should have liked to have wandered about Oxford with you, if I had been well enough——" That was as fortunate: "It is something unintelligible to me how anyone can argue in public like orators do," and this was an occasion for desperate and stubborn, even vindictive, argument.

Unfortunately no stenographic notes of the meeting were taken, so we must depend for an impression of it upon the condensed official records[28] supplemented by the recollections of persons who were present. Two conflicts occurred, both in Section D, presided over by Professor Henslow. The first took place on Thursday, June 28th, occasioned by Dr. Daubeny's paper, "On the Final Causes of the Sexuality of Plants, with Particular

[26] Dorsey states (pp. 193-4) that Huxley sought to avoid the meeting but was induced to stay by Robert Chambers' calling him a "deserter," that he was unprepared to speak, but that he could not resist the bishop's obvious challenge and the opportunity to expose Wilberforce's ignorance. It is interesting to see that Chambers gave evolution more aid here than in his "Vestiges."

[27] Letter to Hooker, July 2, 1860, "Life and Letters," Vol. II, p. 116.

[28] See "Report of the Thirtieth Meeting of the British Association for the Advancement of Science held at Oxford in June and July 1860." "Botany and Zoölogy, including Physiology," No. 2.

Reference to Mr. Darwin's Work on the 'Origin of Species.'"

This weak and cautious paper suggests that blossoms "might have been provided [i.e. by Providence] in order to prevent that uniformity in the aspect of Nature which would have prevailed if plants had been multiplied exclusively by buds"; the author saw that sexuality must be an aid to evolution by leading to variability, and though he "gave his assent to the Darwinian hypothesis, as likely to aid us in reducing the number of existing species, he wished not to be considered as advocating it to the extent to which the author seems disposed to carry it."

Huxley, though invited to discuss the question, declined, for he thought a general audience, in which sentiment would unduly interfere with intellect, was not the public before which such a discussion should be carried on. Sir Richard Owen had more faith that the "public could come to some conclusion with regard to the probabilities of the truth of Mr. Darwin's theory." One of the "facts" cited by him was that there is more difference between the brains of the gorilla and of man than between those of the very highest and of the very lowest of the *quadrumana* (or apes and monkeys). This roused Huxley to a "direct and unqualified contradiction." He pledged himself to prove what he said—and spent three years in preparing his brief, "Man's Place in Nature." Momentarily the storm dissolved.

Two days later the real clash came. Dr. John W. Draper of New York had read an essay on the "Intellectual Development of Europe Considered with Reference to the Views of Mr. Darwin and Others that the Progression of Organism is Determined by Law." [29] This paper, interesting in itself and clearly, forcefully composed, is remembered chiefly because of what followed.

[29] See *Trans. Brit. Assn.*, 1860, for a careful abstract.

Draper was one of the Americans who had followed Asa Gray into an acceptance of evolutionary doctrine and had gone even further. Here he drew an analogy between an individual and a nation, each of which shows a regular course of progress and decay. Greece thus lived through a life divided into five definite stages; and the history of Europe has lived through all of the same periods except the fifth. "A nation is like a seed, which can only develop when the conditions are favourable, and then only in a definite way." He thus completely accepted Darwinism and extended it so as to include that super-organism, the nation.

When the field was thrown open to general discussion, "the excitement was tremendous." A crowd of perhaps a thousand persons, too great for any lecture room, crammed every bit of space in the library. Professor Henslow, as chairman, had ruled against any empty oratory and actually stopped four speakers on this ground.

Then Bishop Wilberforce arose. He had "valid arguments" in plenty to present, though it seemed to some "that he had been 'crammed' up to the throat and knew nothing at first hand." He must have spoken powerfully; even a hostile narrator speaks of his "inimitable spirit," "dulcet tones," "persuasive manner," and "well-turned periods." His arguments were those of the *Quarterly Review,* but the enthusiasm of conflict swept him on to ask "whether Huxley was related by his grandfather's or grandmother's side to an ape."

At this Huxley chuckled and rubbed his hands, remarking to a neighbor, "The Lord hath delivered him into mine hands." His turn came; he was as aggressive an orator as Wilberforce and a better scientist, and he had the immeasurable advantage of a thorough grasp upon the subject. Point for point he met the bishop's arguments and step by step he led his audience to sense the dishonorable nature of Wilberforce's personal sarcasm.

His embattled sentences marched toward a climax. His exact words were not recorded, but they have been quoted by one who was present,[80] to this effect: That a man had no reason to be ashamed of having an ape for a grandfather, but "if there were an ancestor whom I should feel shame in recalling, it would be a *man*, a man of restless and versatile intellect, who, not content with success in his own sphere of activity, plunges into scientific questions with which he has no real acquaintance, only to obscure them by an aimless rhetoric, and distract the attention of his hearers from the real point at issue by eloquent digressions and skilled appeals to religious prejudice."

Three-quarters of a century after that conflict, such a reply would still seem stirring; in 1860 it was incredible. In the midst of a furious outbreak of excitement—during which "a lady fainted and had to be carried out"—Huxley was unable to continue, but he had said enough and said it well enough. He had proven that theories of science must be judged on the basis of fact and reason rather than authority. And he had shown that when a bishop is in the wrong, any plain human being may presume to say so. Darwin himself would never have dared to do it. A few days after the clash he wrote to his champion, "I honour your pluck; I would as soon have died as tried to answer the bishop in such an assembly." There is every reason to believe this only a little exaggerated.

But to return: when order was finally restored, Sir Joseph Hooker was called upon. Speaking more gently than his predecessor, he contented himself with showing that Wilberforce did not understand the "Origin" and was not even a competent botanist.

The meeting ended, but Oxford buzzed that week with

[80] J. R. Green, author of "A Short History of the English People"; see Dorsey, "Evolution of Charles Darwin," pp. 191-2. His account is followed here. See also "Life and Letters of T. H. Huxley."

talk of Darwin and evolution and Huxley. Before long news of the conflict spread, and here and there throughout the world there were sympathetic vibrations. The collapse of a spectacular attack, the unbelievable audacity of the transformist spokesman, made the acme of news-value. To paraphrase a common journalistic truism, if an ecclesiastical authority denounces a scientific theorist, that is not news, but if a scientific theorist denounces an ecclesiastical authority, that is—or was in 1860—news of front-page prominence. "It seems," said Darwin in a letter full of gratitude, "that Oxford did the subject great good." He did not need to complain of men's cruelty to his "puny child," for it had grown strong and self-dependent. Reports from America showed the campaign raging there too, under the generalship of Asa Gray, for evolution and of Agassiz for special creation. That great naturalist, who wrote as readily in French as in English and who was revered in his day as much as Humboldt or Cuvier in theirs, never ceased his opposition to the entire evolutionary scheme and all its implications. In Germany, Von Baer, du Bois Reymond, and Bronn led a growing array in the cause of "Darwinismus."

The author of the "Origin" did not rest on his completed work. It will be recalled that he regarded it as a mere abstract of a fuller treatment to follow, and he meant to finish that greater work, giving his facts and details on the subject, though it might cost him ten years more. Actually it took almost fifteen years and involved the writing of three large books. It influenced to some extent every bit of work he did from that time until the end of his life. His next major work did not appear until nine years after the "Origin." During that interval other men were writing other memorable books touching on related subjects.

Of these an early and much debated example was a volume made up of seven separate contributions by a

group of the more progressive clergy. It was given the non-committal name of "Essays and Reviews," "a very significant volume with a very insignificant title." [31] In discussing the emergence of this book and some contemporaries, such as the "Origin," Bishop Colenso's critical treatment of scriptural chronology, Spencer's prospectus for a series on the evolutionary philosophy, and others that brought literal faith into question, Leslie Stephen reminds us [32] that "it has become difficult to realize the greatness of the shock" transmitted by "'the seven against Christ' as the authors of 'Essays and Reviews' were pleasantly called."

The essays all treated of questions more or less theological, and the treatment was in every case more or less liberal. What has come to be known as "the higher criticism" of religion was thus introduced into England under the influence of German thinkers such as Bunsen. Benjamin Jowett (1817-1893) the translator of Plato, was the most famous of the contributors, though his purely theological "Essay on the Interpretation of Scripture" need not detain us here. Mark Pattison's (1813-1884) account of the "Tendencies of Religious Thought in England, 1688-1750," was the most pretentious essay, and Walker [33] has called it "the most memorable of all the papers contained in the volume." As all the contributors were officials of the Established Church, and thus of the government, the two whose declarations were most dangerous were prosecuted, but could not be found guilty.

The volume touches our subject, in part, because people felt toward it the same terrified fascination which was roused by the "Origin," in part because of some of its contents. Baden-Powell, scholar, F.R.S., and Savi-

[31] From the Preface to the American edition, edited by F. H. Hedge, D.D. (First edition, 1860.)
[32] "Some Early Impressions," p. 55.
[33] "Lit. Victorian Era," p. 108.

lian Professor of Geometry in Oxford, expounded his views "On the Evidences of Christianity." Most apposite of all is C. W. Goodwin's treatise "On the Mosaic Cosmogony," for this dealt directly with matters of natural knowledge. The author reviews the various attempts of Chalmers, Buckland, Hugh Miller, and Archdeacon Pratt to reconcile Genesis and geology, finding fault with each. However, all such attempts agree in one respect,[34] for they all "divest the Mosaic narrative of real accordance with fact; assume that appearances only, not facts, are described, and that in riddles; which would never have been suspected to be such, had we not arrived at the truth from other sources." Yet the author is no skeptic; in regard to faith and morals he is perfectly "sound," merely choosing to delimit the sphere of religion so as to put scientific matters out of bounds. He suggests[35] that we should "regard it [Genesis] as the speculation of some Hebrew Descartes or Newton, promulgated in all good faith as the best and most probable account that could be then given of God's universe . . . not an authentic utterance of divine knowledge, but a human utterance, which it has pleased Providence to use in a special way for the education of mankind."

The first article, entitled "The Education of the World," came from the pen of Frederick Temple, D.D., Chaplain-in-Ordinary to the Queen, Headmaster of Rugby School, and so forth, and thus a personage of some standing. It was he who preached the sermon on July 1, 1860, before the University of Oxford during the meeting of the British Association. That oration, on "The Present Relations of Science and Religion," is given in the appendix to the volume. It is interesting as a frank though a diplomatic analysis of the situation. Its keynote is this: "theology has begun where science has ended"; thus

[34] "Essays and Reviews," p. 274 (Amer. ed.).
[35] *Ibid.*, p. 277.

science has found specific causes for definite results, while theology has deduced an infinite First Cause of all. Parallels between the two are indicated: both imply the lapse of uncounted ages, the waste of unmeasured living hosts. Above all he pleads for more tolerance and suggests finding God in general laws rather than in individual acts. Such are the scientific portions of a book not intended as science but showing an intelligent awareness of progress in the understanding of nature.

Far more significant for those in a position to understand was the publication of Sir Charles Lyell's monumental work, "Geological Evidences of the Antiquity of Man, with remarks on Theories of the Origin of Species by Variation." * Lyell had reached a ripe old age and was universally respected as the chief of living English geologists. His own early struggles for the uniformitarian [36] view of natural history had been conducted so moderately and so tactfully as not to damage the author's reputation even with conservative readers. Those struggles were long since ended. Lyell had considered Lamarckian ideas of transformism, while writing his "Principles of Geology" thirty years before, had realized that the organic world has always been and is still in a state of progress, but he could not acknowledge that any satisfactory explanation of that progress had been given. He understood the struggle for existence, the pressure of living forms upon one another. Yet his best explanation was to say that the succession of life occurred "as if" created. As Darwin's friend and "lord chancellor," he had been familiar with the latter's researches almost from the beginning, had forced him to present his work together with Wallace's before the Linnean Society, had permitted his name to be used in the introduction to the "Origin," yet he had never accepted the ideas of his friend either in public or in private. At least one reviewer of the "Origin"

* (1863.)

[36] See Chapter III above.

had appealed confidently to Sir Charles to put down the upstart doctrine.

It was only after that book had been published and he had studied it in detail that Lyell allowed himself to be "*per*-verted," and then only with reservations. His adherence was one of the cheering circumstances that made Darwin feel sure of his own ideas. Now Darwin had carefully avoided the entire subject of man's origin as one too surrounded with prejudice, hinting only, for the sake of honor and frankness, that light would be thrown "on the origin of man and his history." That hint was taken boldly by Lyell.[87] From his own stores of geological knowledge, now redirected along the lines of a new principle, he reconstructed the prehistoric life of the human race.

This book, which carried all the authority and was written with all the literary skill of its author, did much to make evolution acceptable to many minds. Darwin himself declared that the fact of Lyell's adherence would win more goodwill than all the reasoning in the "Origin." However, when the "Antiquity of Man" appeared, he was "deeply disappointed (not personally) to find that his timidity prevents him giving any judgment" strongly for evolution. Lyell had again exemplified his characteristic caution by publicly accepting the new idea in such mild terms as to give no offence.

The book itself is far more than a milestone to mark the progress of a theory. It is a rich store-house of knowledge, organized for ease and usefulness in reading. Its ingenious plan presents ideas according to the method of discovery, as if the reader were himself following the excavation, the surface first, then the deeper strata. Suffice it to say that in structure and style the book shows the artistry of an author who wrote to be read, not despising lay readers, who did not smear "the fair face of

[87] Also by Huxley. See pages 242-244.

truth with that pestilent cosmetic, rhetoric," nor mar it with unbecoming lines and blemishes, but who fitted a lucid and dignified manner to a worthy substance. Long before he had been classed among "those authors who educate people's minds as well as teach them special facts." [88] Even in his old age, the geologist remained the author who had declared "I must write what will be read."

It was remarkable enough that he had reversed his former position and now acknowledged that he believed in evolution. It takes courage for a man prominently in the public eye to admit that what he has been preaching for thirty years was wrong. Yet this is what Lyell did, and however cannily he may have moderated his declaration, it placed him upon the unpopular side in what, to approximate Lord Beaconfield's *mot,* may be called the war of apes against angels.

His first great work, "The Principles of Geology" and its progeny, the "Elements" and the "Manual," continued to appear in newer and freshly revised editions, and every reissue of these works after 1863 showed the influence of evolutionary thought. Even the titles of later editions were recast to fit the new situation. The wisdom of his temperate way was again illustrated; Lyell drew but little of the lightning to himself, helped smooth the path for Darwin, and died (in 1875) after a full, rich life, laden with honor.

No such moderation of spirit could be found among the qualities of Huxley, "Darwin's bulldog" and self-styled "agent for the promulgation of damnable heresies." Like Lyell he had considered evolution not proven until the "Origin" appeared, when, unlike Lyell, he had instantly and wholly leapt to its defence, "prepared to go to the stake" for it. When he flatly contradicted Owen's statement (at Oxford) that man's brain was further from

[88] 1845; see "Life and Letters of Darwin," Vol. I, p. 306.

the gorilla's than that of the highest ape from the lowest monkey, he had to pledge himself "to justify that unusual procedure elsewhere," for he was not then in a position to prove his statement.

He had, however, been studying that very question ever since he first heard of the views of Darwin and Wallace—two years before, almost to a day. Immediately he began to organize the materials and to collect more. In the intervals of his regular work as professor at the Royal School of Mines, curator of fossil collections in the Museum of Practical Geology, and editor of a new natural science review, he beat some of these materials into a course of lectures to working-men, "On the Relations of Man to the Lower Animals." That was as early as 1860. In 1862 a more technical series on the same subject was given before the Edinburgh Philosophical Institution. In 1863 a selection of these lectures was published entitled "Evidences as to Man's Place in Nature." This was the first clear statement that man was descended from an ape-like ancestor. The work of Darwin and his fore-runners had been fearfully surmised by many to point the way, but it was not explicit. Huxley, whose definition of morality was always to speak the truth and whose basic principle of style was to "be clear though you may be convicted of error," did not evade the issue. Rather he sought it, forced it. Conservatives, who had been whispering that evolution might yet link man with the beast, here had it given to them directly, without extenuation. Huxley succeeded here, as he so often did, by the force of energy and audacity, coupled with real knowledge.

"Man's Place in Nature" is not the best of his writings, nor the most characteristic. Made up of two separate groups of lectures, it is unequal—now heavy with anatomical technicality and again very simple, forceful, and plain-spoken—and it contains much repetition (also in-

teresting stories and descriptions of the habits of apes). As a whole, therefore, it is not a well-rounded or balanced work, but a group of loosely related separate essays, historical, anatomical, physiological, psychological, all explaining and enforcing "the impossibility of erecting any cerebral barrier between man and the apes," implying that "even the highest faculties of feeling and of intellect begin to germinate in lower forms of life." Huxley had thus unmistakably placed man among the phenomena of nature and accounted for both soul and body as products of evolution. He had tossed Owen's subtle scheme for classifying mammals solely according to their brains into the rubbish-heap and with it Owen's elaborate and half mystical elevation of man above the rest of nature. He had made some actual discoveries, such as that the *hippocampus minor* is found in the brains of both man and ape.[39] And he had written not merely so that he could be understood but so that he could not be misunderstood. He had affirmatively taken the common man into the councils of scientific leaders.

Some years earlier, Huxley records, he knew of no first-rate thinker who believed in the truth of evolution except Herbert Spencer. It has been seen how aggressively that philosopher advanced the view, how grandiosely he was planning to elaborate it into a general doctrine of all existence. In later years he resented the common custom of identifying evolution with Darwin and ignoring his own prior and more far-reaching connection. His autobiography contains a letter to John Stuart Mill, who was an official of the India House as well as a leading economist, asking ingenuously for a position with income large enough for a writer's "modest bachelor requirements" but with duties so nominal as not to interfere with his spending many years in preparing a vast series of

[39] For a comic parody of this controversy, see Kingsley's "Water Babies."

works on the "synthetic philosophy" that he was contemplating.

As no such sinecure was forthcoming, Spencer issued a prospectus outlining the work he planned and calling for subscribers. To them he made definite pledges of portions of the work at stated times. It was in this periodical form, just then much in use for the novels of Dickens and Thackeray, that Spencer's ambitious "First Principles" appeared. (1862 and 1867.)

In one way, at least, this volume is his most important. Spencer's quest for ultimate Truth led him to an unbounded respect for abstraction. The more numerous separate phenomena that can be summed up in a generalization, the nearer does that generalization come to universality. Thus we have found him [40] seeking laws "which hold not of particular kinds or classes of organisms, but of all organisms." Again in his "Classification of the Sciences," [41] he insists on the importance of abstractness and generality in the key-sciences. Now the ideas expounded in "First Principles" are such as should apply to *all* the lesser sciences equally, however unlike one another these may be. So this book may be considered the actual corner-stone of his system. One is mired in any attempt to classify it, but perhaps it belongs most comfortably in the fields of philosophy and logic.

Part I, on "The Unknowable," analyzes ultimate religious and ultimate scientific ideas, sympathetically enough, and suggests their reconciliation by dividing the scope of their activities. Part II treats of "The Knowable," or the real field of science, in highly generalized form, including, of course, his well-known general doctrine of evolution. Of this he tells [42] us that "there are not several kinds of Evolution having certain traits in common, but one Evolution going on everywhere after

[40] In "Transcendental Physiology." See chapter X above.
[41] 1864.
[42] "First Principles," p. 501.

the same manner." Owing to the instability of all homogeneous matter it is always tending to evolve into forms more heterogeneous, until an ultimate point is reached, after which no more complication is possible and dissolution must set in.

The real question attacked was the old puzzler: "How do we know that we really know anything?" Spencer accepted the Hamiltonian demonstration that all knowledge is relative. The three great scientific generalizations, however, of gravitation, the nebular hypothesis, and the conservation of force, could all be united into one, and that one was evolution.

The style of his writing shows the public orator turned heavy thinker. That Spencer was sensitive to matters of style we know from his essay on that subject. His great popular following and the immense influence he wielded show that he knew how to write attractively as well as clearly. One has only to read certain of his essays, such as the early Haythorne paper [43] on "The Development Hypothesis," to feel his power and to see how his effects are attained. Some of this skill is present in "First Principles," but much is sacrificed to the need of discussing "realities that cannot be comprehended." His literary vices have been thus outlined by the Duke of Argyll: [44] "Besides the method of habitually using words so abstract as to be of necessity ambiguous—besides the further method of habitually expelling from definite words the only senses which give them value—Mr. Spencer often resorts to the scholastic plan of laying down purely verbal propositions and then arguing deductively from them as if they represented axiomatic truth." The duke was hostile, and it may be unfair to call Spencer's propositions "*purely* verbal," but the stylistic complaint is sometimes legitimate.

[43] See Chapter X above. [44] In "Organic Evolution," p. 55.

Spencer lived up to the pledge made to his subscribers. The second great stage of his vast structure of thought was reached two years later * when "The Principles of Biology" was published. This was a less generalized and ultimate scheme of thinking than the "First Principles," for it applied those same principles within a finite field. Yet the Preface declares: "The aim of this work is to set forth the general truths of Biology, as illustrative of, and as interpreted by the laws of Evolution: the special truths being introduced only so far as is needful for elucidation of the general truths." Notice the last phrase, for it states Spencer's real motive and attitude.

It fills two volumes and is divided into six parts: "The Data of Biology, the Inductions of Biology, The Evolution of Life, Morphological Development, Physiological Development, and the Laws of Multiplication." The remarkably synthetic structure of this work is perhaps without peer, for in this book the author proceeds from the hypothetical *monad* to an integration of the entire world of life. It is important to understand what he was trying to achieve so as to see how thoroughly he has done it. Others, before and since, have written more full, more accurate, or more picturesque text-books on biology. It was left for Spencer to work out a systematic application of what he considered final truths to the principles of a particular science. If there is more principle than biology in the book, remember that Spencer was not essentially a biologist, was essentially an organizer of knowledge, that to him, as to many other of the best minds, the broad view and the arrangement of learning are far more important than the detailed facts of any one science. Darwin admired, was dazzled and perplexed by the boldness of thought shown by his great contemporary. After reading the "Principles of Biology" he declared [45] its

* (1864.)

[45] "Life and Letters," Vol. II, p. 239.

author "about a dozen times my [his] superior." At a later date [46] he wrote to Spencer, "Every one with eyes to see and ears to hear (the number, I fear, are not many) ought to bow their knee to you, and I for one do." Yet plain man of science that he was, he could never outgrow a certain distrust of the tremendous deductions and sweeping generalizations that mark Spencer's work.

[46] July 1872, concerning Spencer's "Mr. Martineau on Evolution," in *Contemporary Review*.

CHAPTER XVI

BRINGING UP THE REAR

Darwin himself had not forgotten his determination to work up the facts and details upon which the "Origin" was based and some of which he had asked its readers to take on trust. Almost from the day of publication, he began to revise his book for a second edition, and, as soon as this necessary task had been done, he again set to work on the deferred project of a complete Great Book of which the "Origin" was an abstract. Naturally the first section would deal with domesticated animals and plants, and this section alone grew so large that the author soon realized the impossible, overwhelming bulk of his book. So that plan was dropped, and instead a whole library of works on various phases of organic evolution began to take form.

Long before this Darwin had realized the insufficiency of his botanical knowledge. And even later, when he was awarded a medal for his discoveries in botany, he could not get over his amazement and amusement at such recognition coming to so ignorant a botanist. Now he needed knowledge of this subject, so he sought it combined with recreation from his more serious work by the riding of several "hobby-horses." That is, he worked hard at real questions not directly necessary for the solving of his major problem. He always considered these lesser investigations as pure fun, especially if they involved much observation and experiment and little writing. So he had a greenhouse built on his grounds at Down, with a little work-room attached, and he started

to study the fertilization of orchids. Shortly he had learned enough about this matter to write a book of moderate size upon it. The volume,* which intentionally treats of a small subject, has none of the packed fulness of the "Origin" nor any of that book's sense of grasp upon a mighty truth. In fact it is but the expansion of a single point mentioned in one brief sentence in the greater book, which he had been criticized for neither proving nor illustrating. Its object is "to show that the contrivances by which orchids are fertilized are as varied and almost as perfect as any of the most beautiful adaptations in the animal kingdom; and secondly to show that these contrivances have for their main object the fertilization of the flowers with pollen brought by insects from a distinct plant." Matters of contrivance and adaptation may be products of natural selection, so the connection of this with his greater work is clear.

In other respects it stands quite apart. It is not a large book and is composed with leisurely casualness. Its various chapters, except the last, are more or less parallel accounts of various genera. The book was written for botanists with conscious "fear that the necessary details are too minute and complex for anyone who has not a strong taste for natural history." Yet the introduction gives the "meaning of the common terms used," and the reader is assured "if he will have the patience to make out the first case, the succeeding ones will be easily intelligible." The explanation, for instance, of how the entire *polinium* adheres to the insect, the visualization of a moth's proboscis by comparison with a pencil, make for clarity and interest. There are personal touches, references to "my son George," for example, narratives of his own experiments and observations, his own inspecting of the heads of many insects and finding pollen-cases attached—lively, homely touches which not only "record

*"The Various Contrivances by which Orchids Are Fertilised by Insects" (1862.)

observations of fact" but also "transfer experience" and are thus part of a work of literature.[1] In this we see Darwin in a new rôle, as the investigator of a comparatively small matter, as the writer with but little of a message, yet doing that little with a whole heart. His remaining botanical works were composed in the same mood, which is one of his happiest and most characteristic.

Not until 1868 was he able to publish his two-volume work on "The Variation of Animals and Plants under Domestication." It is the factual evidence in support of Chapter I of the "Origin," a massive buttress, so large and full that one can understand why the Great Book had to be abandoned, why a corresponding work on variation in the wild state (to support Chapter II) referred to here, was never written. Asa Gray's preface (to the authorized edition) calls it "a perfect treasury of facts . . . principles . . . laws. . . ." By rights it is one of Darwin's greatest books and contains some of his best writing.

The structure is simple, the first volume being given over to a presentation of facts and directly related conclusions, its separate chapters devoted to studies of the several kinds of animals and plants, while the second volume goes into a thorough discussion of the underlying forces and the more sweeping conclusions. In both parts he writes with a sense of freedom and scope to parallel which one must go back to the unpublished essay, without any of the cabin'd, cribbed, confined suppressions and eliminations that make the "Origin" so hard a book to exhaust. He is treating a large subject in a large way, telling all he has been able to learn about each least portion of it and "spreading himself," too, in dealing with its larger issues.

The subject of domestic animals and plants lent itself particularly to his homespun genius. He was a devoted

[1] See Rickert, "New Methods for the Study of Literature," Chapter I.

dog-lover, had bred pigeons, kept horses, and grew plants on his estate. The sounds and smells of the barnyard are in this book, perhaps not altogether intentionally but with real advantage for the general reader. The writing is delightfully clear, even beautiful, and there is a sort of gallantry in the author's approach: he speaks with conviction, force, scope, and grace. The multitude of facts is given with charm and variety, safely avoiding the danger of lapsing into mere catalogues. He has an eye for picturesque illustration; strangely, even what he quotes from others seems chosen for the same qualities. Like his grandfather's "Zoönonia," this book calls together from widely separated sources many illustrations for each general statement. All was grist that came to his mill, whether brought by his own experience, reading, rustic traditions, the reports of correspondents in many parts of the world, or race-track records. His citations naturally come in the main from the works of biologists, but they involve sources as various as Confucius, Gervase Markham (1631), the Bible, Homer, Virgil, Athelstan, Cormac, Akbar Khan, Cardinal Ximenes, Varro, James Fenimore Cooper, and de la Vega of Peru. Darwin always preferred the title of "naturalist" to that of "scientist," and with reason; his works give a picture of nature, entire and living, rather than a laboratory analysis or dissection. Some knack in him led to taking hold of the questions he dealt with so that the imagination can take hold with him, can realize and share the experience, can be stirred or comforted by a penetration of the secrets of nature.

Scientifically, the book's chief value lies in its array of sustaining facts to bear out that phase of the evolutionary hypothesis about which it is most possible to gather facts. "Man [3] may be said to have been trying an experiment on a gigantic scale; and it is an experiment which nature

[3] "Variation and Domestication," p. 13.

during the lapse of time has incessantly tried. . . . The principle of selection is all-important. Although man does not cause variability and cannot even prevent it, he can select, preserve, and accumulate the variations given to him by the hand of nature in any way which he chooses; and thus he can certainly produce a great result." A professional breeder is cited [3] who holds that one "should make up his mind to the shape and qualities he wishes to obtain, and steadily pursue that object."

In certain respects this book shows the development of the author's ideas that had taken place during the nine years since his theory had been made public. For instance, he is rather uncomfortably aware that "natural selection" is an unscientific, too figurative term, attributing a human consciousness to automatic natural processes. Its lack of desirable abstractness had been impressed upon him by Herbert Spencer, whose suggested term, "survival of the fittest," he admits to be preferable. Yet, after flirting with this and with "natural preservation," he comes back to "selection," though with warnings not to take it literally; after all, it is a more vivid and picturesque name for what nature seems to do.

Darwin had never insisted that natural selection is the only force at work in evolution. But here he showed a growing inclination to recognize also the other influences suggested by Lamarck and Geoffroy Saint-Hilaire as causes. For example, he declares,[4] "It would appear that climate to a certain extent directly modifies the forms of dogs." Lamarck, Buffon, and other early naturalists had great faith in the direct influence of climate, and it was largely his dissatisfaction with this explanation that had sent Darwin to seek other explanations. His admission here that the "Lamarckian factors" were of some

[3] "Variation and Domestication," Chapter XX, p. 236.
[4] *Ibid.*, p. 53.

(though not great) importance is an orderly withdrawal from the extreme "Darwinian" position still held by Wallace and others. And again, he considers [5] that the legs of the turnspit, like the bulldog's jaw, "have probably arisen suddenly, and, though strictly inherited, may be called monstrosities." This is admitting an exception to his usual rule of infinitesimal variations accumulating by long inheritance. Such sudden changes, known as *mutations* or *saltations,* had been suggested by Geoffroy Saint-Hilaire. Long afterward [6] (1904) the idea was to be rediscovered by De Vries, leading to the pronouncement that "Darwinism is dead" and misleading many into supposing the whole hypothesis of evolution disproved. As a matter of fact, Darwin himself here granted that mutation had played a certain, though inferior, part in evolution. He further conceded the effects of use and disuse or of training in both dogs and rabbits and of food in changing the size and form of horses.

His theoretical chapters make many matters clear by full statement. Chapter XVII, "On the Good Effects of Crossing and on the Evil Effects of Close Interbreeding," makes the contact between his purely botanical work and the larger issue.

Near the end of the book, rather irrelevantly, he presents his provisional hypothesis of *Pangenesis.* This idea, which was supposed to explain how descendants inherit qualities from their parents, is one of the few real failures in Darwin's career. He presumed that "gemmules" from every part of the parents' bodies came together in the seed, which thus transmitted all qualities to the offspring. The theory came "still-born" from the press and won scarcely a single adherent. The acceptable explanation of this mystery was then being worked out—but was to wait a generation to be published [7]—by the Tyrolean

[5] "Variation under Domestication," p. 54.

[6] "Species and Varieties, Their Origin by Mutation."

[7] Mendel's conclusions were given in "The Proceedings of the Nat. Hist. Soc. of Brünn" in 1866 and 1867, but were unknown elsewhere.

monk, Gregor Mendel. Darwin's explanation showed many curious points of similarity with Mendel's, but he did not have enough real basis for generalization. For once he had been too deductive, too sweepingly inductive. So it is pleasing to note that he at least made no unjustified claims. "I am aware," he writes,[8] "that my view is merely a provisional hypothesis or speculation; but until a better one be advanced, it may be serviceable by bringing together a multitude of facts which are at present left disconnected by any efficient cause." Perhaps it attained this modest aim. Perhaps even, by calling attention to the subject, it led to those further discoveries that have definitely eliminated pangenesis; certainly the two leading geneticists of the period were familiar with this hypothesis before attacking the problem themselves—Francis Galton, as Darwin's cousin, and August Weismann, as one of his severest critics.

With the passage of years, Darwin learned to write faster. His next great work, "The Descent of Man and Selection in Relation to Sex," * usually bracketed with the "Origin" as one of his two best books, took but three years of continuous work. It is true that he said [9] "the work half-killed me, and have not the remotest idea whether the book is worth publishing," true that it is much smaller than the "Origin" and far less compact, that its field is rather more limited, and that the groundbreaking no longer had to be done. This book was bolder in that it came closer and more directly to a subject that stirred people's resentment; even Wallace, for example, refused to apply the theory of natural selection to the human soul. Darwin was not satisfied to treat man as the one miraculous exception to an otherwise universal process. Said he: [10] "The sole object of this work is to

[8] "Variation under Domestication," pp. 428-9. * (1871.)
[9] "Life and Letters," Vol. II, p. 311.
[10] "Descent of Man," p. 3.

consider, firstly, whether man, like every other species, is descended from some pre-existing form; secondly the manner of his development; and thirdly, the value of the differences between the so-called races of man." It may thus be considered as a further extension of the ideas of the "Origin," or even—since it was planned originally to be a chapter in the book on "Variation" and since a large part of it deals with sexual selection *throughout the animal knigdom*—it seems to be part of the series that replaced the planned Great Book.

A burst of shocked astonishment might have been expected, had not the dozen years between the "Origin" and the "Descent" been full of premonitions. Works by Huxley, Spencer, Lyell, Lubbock, Haeckel, Bates, Wallace, and Tyndall had appeared in the interim, and some of them were quite outspoken, stealing their Olympian's thunder. Further there had been many books and many articles written to oppose Darwinism—such as Dr. Bree's "Species Not Transmutable" (1860), Owen's detailed three volumes "On the Anatomy of Vertebrates" (1866), the Duke of Argyll's "Reign of Law" (1867) and "Primeval Man" (1869), Bishop Perry's "Science and the Bible" (1869), St. George Mivart's "Genesis of Species" (1870), and W. H. Hudson's nine early letters to the Zoölogical Society on "the Ornithology of Buenos Aires" (1870). The very opponents of Darwin had anticipated many of his conclusions, thus acting as buffers when he finally declared man's descent. Nevertheless, he was "much abused" for it by the *Quarterly*—"so savage and Tartarly," to quote Byron,—and the *Edinburgh Review* described its reception thus: [11] "On every side it is raising a storm of mingled wrath, wonder, and admiration." As the author said when the "Origin" appeared, he "got more kicks than halfpence." The "Descent" was an important work in every sense, yet it did not of itself herald

[11] See "Life and Letters," Vol. II, p. 313.

a revolution in thought, as the "Origin" had done, and the stir it made was less.

The book is divided into three parts, one on "the descent or origin of man," giving the expected arguments from embryology, comparative anatomy, and psychology, a second disproportionately large part on "sexual selection," and a third brief section applying these newly developed principles to mankind.

Had this work been conceived simply as a treatise on the origin of the human species, Part I would have sufficed and the result would have been better balanced, more unified, and complete enough. The long, compendious discussion of sexual selection had to be given here merely to account for the development of the "so-called races" of man. But there was another motive for its publication. Darwin had long been painfully aware of organs and structures not serviceable to their possessors, such as the cumbrous decorative tails of peacocks and pheasants, and therefore not explicable as products of natural selection. These were a sore trial to him; shortly after the "Origin" was published, he wrote [12] that the sight of a feather in a peacock's tail made him sick. But by 1864 he had thought of a solution: those individuals possessed of features which, however senselessly, seem attractive to the opposite sex are thereby enabled to mate earlier and more often and more desirably than others and thus in the course of generations to stamp their own form upon all members of their sex and species. This principle he called sexual selection, and found it useful to explain all sorts of inefficient but beautiful developments among animals, all sorts of "secondary" differences between the male and female of the same species. One may even maintain that beautiful and sweet-smelling flowers have been developed by the sexual selection of the bees that make cross-fertilization possible.

[12] "Life and Letters," Vol. II, p. 90.

The same process accounts for the beard of man, the lion's mane, the gorgeous tails of many tropical birds. A related principle—, "the law of battle," recognized and named by Erasmus Darwin—explains the possession by males of certain special weapons which are used to full value only in combat with other males of the same species for the possession of the females. Such are the enlarged canine teeth of stallions, the tusks of bull-elephants and walrus, stags' antlers, and, to some extent, the greater size and strength of most males, including men.

Now all this is full of interest and significance, but to a student of the descent of man it seems a lengthy digression, altogether bigger than its connection with the subject would justify. Its inclusion here can be better understood if we regard this book simply as installment No. 3 of the series, its special topics being two; namely, 1, the descent of man, and 2, selection in relation to sex. It was especially fitting that Darwin's theory, which made so much of nature's unconscious selection by the survival of the fittest, should be completed, not by another explanation altogether, but by a second kind of selection through the race-survival of the most attractive.

Probably the most unexpected, original, and daring part is that which compares the mental powers of man and the lower animals. This is one of the earliest attempts to examine the mind objectively like any other phenomenon in natural history. Darwin had the simple, sincere nature that made it possible for him to form contacts with animals, children, and savages, and these were actually the creatures whose minds he had to understand. He pointed out that the mind of an ape must not be compared with that of a Newton or a Shakespeare but with that of the most primitive savage, just within the boundaries of humanity. Even then, the difference is immense, but he maintained that it was a difference of degree and not of essential nature. We hold our instincts

and emotions quite in common with the other higher mammals, and even the power of reasoning and the social and moral instincts are not exclusively human. He explained conscience—that seemingly miraculous still, small voice—as having been developed by natural selection of a social sort: those tribes among whom a strong sense of duty prevailed over personal temptations must in the long run have been safest and so fittest to survive. He decides against the view that the various human races are really separate species. All men are blood-brothers; local conditions having caused some variation, the differences have been multiplied and increased by sexual selection, since among any nation the individuals strikingly typical of the nation are preferred in matrimony.

The literary style is not markedly different from that of the "Variation" and need not detain us here. There are stretches too detailed for the general reader, as well as much that any educated person of alert mind must read with fascinated delight or comfortable pleasure. This book, unlike the "Origin," is thoroughly documented with footnotes and citations and abounds with that wealth of specific information and that neatness and scope of reasoning which we have come to expect. It is written more boldly than the "Origin," with less of the concession to official opinion that was no longer so necessary.

While working over the material on the evolution of mind, the author became interested in a comparison of the expression of emotions among man and animals. At first he planned to include this topic in the volume on "Descent," but when it proved too large for that, he made a "hobby-horse" of it, which he rode for fun while working at the other. It had been an old favorite of his: soon after his first child was born, he had begun making notes of the baby's expression, and now, while writing the book, he had a two-year-old grandchild to compare—discreditably—with a young monkey. He began to write

on this subject two days after finishing the last proofs of "The Descent of Man." A year after the issuance of that work, "The Expression of the Emotions in Man and Animals" * was given to the public. It sold quickly and widely at first, but interest seemed to dwindle after a time, so that no second edition was published during his lifetime.[13] Opinions concerning it differed. Thus Wallace, reviewing it for *The Quarterly Journal of Science,*[14] said that this work shows the "characteristics of the author's mind in an eminent degree," such as "the insatiable longing to discover the causes of the varied and complex phenomena presented by living things." On the other hand, in a criticism which its victim called "magnificently contemptuous," the *Edinburgh Review*[15] had this to say along with much more of the same tenor: "Mr. Darwin has added another volume of amusing stories and grotesque illustrations" . . . betraying . . . "a marked falling off both in philosophical tone and scientific interest." Both the *Athenæum*[16] and the *Times*[17] shared this taste. Since that time, the "Expression of the Emotions" has largely won its way back into critical favor. It is viewed as an important work, though never ranked with the "Origin" and the "Descent" either for many-sidedness or for originality. Dr. Dorsey, a leader among behaviorists, declares[18] that "even in the realm of psychology he was in some respects sixty or seventy years ahead of his time. But it is too much to expect that he would try to find a substitute for the concept 'mind,' for example, which as a pure behaviorist he was entitled to do." However, it does seem that he recognized the excessive subtlety of trying to "put a rubber-stamp on a ghost" and so concentrated on the *expression* of

* (1872.)

[13] This despite his having collected many notes for a revision of it.
[14] Jan. 1873. [15] April 1873. [16] Nov. 9, 1872.
[18] "Evolution of Charles Darwin," p. 237. [17] Dec. 13, 1872.

emotions—which can be observed and classified—rather than upon the elusive emotions themselves. The comparison of the minds of man and animals, begun in the "Descent," is continued in the "Expression," which thus appears as one more—the last actually written—portion of the series on evolution. The other projected studies, such as that on variation in the wild state, were never completed, and so we may conclude that, had he gone on to the writing of his Great Book, he might not have lived to finish it. Wallace's irruption, forcing him to prepare an "abstract" as soon as possible, thus saved his work from being dissipated in a course of probably futile accumulation.

The preparatory study was definitely inductive. It began with the collection of facts, this time based upon a questionnaire. But the structure of the book is definitely deductive. It begins with an enunciation of three basic principles which account for most expressions, and this is followed by special applications. This convenient, somewhat formal, logical way of arranging ideas lends itself to a formality of style throughout, often relieved by characteristically vivid yet accurate descriptions that have the breath of life in them. For example, there is [19] "a young lady earnestly trying to recollect a painter's name, and she first looked to one corner of the ceiling, and then to the opposite corner, arching the one eyebrow on that side; although, of course, there was nothing to be seen there." There is the dog "with a hot-house face," the dog that raised one forefoot while listening intently, the fighting hyænas [20] that "approach each other kneeling, with their legs turned as much as possible inwards, and with their whole bodies bowed, so as not to present any salient point." There is the war-horse snorting, not to smell the battle from afar but to permit more violent

[19] "Expression of the Emotions," p. 33. [20] *Ibid.*, p. 125.

breathing. There is an exact description, such as only an experienced parent could give, of a child's face in the act of screaming. Like William James,[21] Darwin declares [22] "most of our emotions are so closely connected with their expression that they hardly exist if the body remains passive."

All these and more curious details—"amusing stories . . . grotesque illustrations" are not piled in pell-mell, but marshaled deductively under three great principles: "1. The principle of serviceable associated Habits" (as when one turns up the nose in disgust, originally to exclude an offensive smell), "2. The principle of antithesis" by which,[23] "when a directly opposite state of mind is induced, there is a strong and involuntary tendency to the performance of movements of a directly opposite nature, though these are of no use; and such movements are in some cases highly expressive," and 3. "The principle of actions due to the constitution of the Nervous System, independently from the first of the Will, and independently to a certain extent of Habit." The principle of antithesis, probably the hardest to grasp, is illustrated by dogs and cats, when pleased, adopting a bearing totally useless except that it is the opposite of their respective hostile attitudes. The third principle, that of direct nervous action, is exemplified by trembling,[24] which "is of no service, often of much disservice." The sensibly objective character of the observations, taking a part of the soul into the province of exact scientific study, is primarily what makes the book noteworthy.

[21] "Psychology."
[22] "Expression of the Emotions, p. 247.
[23] *Ibid.*, pp. 28-29.
[24] *Ibid.*, p. 64.

CHAPTER XVII

"HOBBY-HORSES" OF A RETIRED NATURALIST

After thus doing all that he was destined to do for the series of works on evolution, Darwin, whose pitifully poor health began to improve in old age, turned with increasing gusto to his botanical "hobby-horses." Lamarck had been able to bring a keener insight to the affinities and relations of animals through having been a botanist before he approached zoölogy. In like manner Darwin's life-long training in dealing with animals helped him to see plants in a new way—with more individuality and character than is usual. All his works of this group show the plant as an active being ever up and doing, struggling, climbing, evolving, capturing insects, mating, varying, living. It was one of Darwin's special gifts that he saw nature whole, the minds of man and beast not isolated but blending into one another, the life-habits of animals and plants analogous, governed by basically similar ruling forces.

The first of the botanical series—on the fertilization of orchids—has been discussed above. It was written as a relaxation after the tense work of the "Origin" just as the others marked a sort of partial retirement from the great endeavor of his life. The next such work was "The Movements and Habits of Climbing Plants," * which first appeared as an essay in the *Journal of the Linnean Society* (Vol. IX, 1865) and ten years later was "reproduced in a corrected and, I hope," he wrote, "clearer form, with some additional facts. The illustrations were drawn by my son, George Darwin." The plan of this

* (1875.)

small book is exceedingly simple. The five chapters present observations on four types of climbing plants, followed by a conclusion which theorizes upon the facts. Though there are a few tables of statistics on kinds of plants and their rates of growth, much of the book is written so that it can be read with ease and pleasure. That this was intentional must be evident. Thus, near the beginning,[1] one reads: "My observations will be best given by taking a few special cases," and again,[2] "I will conclude my account of twining plants by giving a few miscellaneous and curious cases." Here the author is evidently aiming at the sound literary method of selection and isolation of material. Much of the book is narrative, telling step by step of the experiments performed and the observing done just as it was done, often with pleasant personal touches. Thus he tells how he timed the twining of a plant and found it to be "2 hours 8 minutes for each revolution," how he "kept a potted plant, during the night and day, in a well-warmed room to which [he] was confined by illness." This plant is individualized and each revolution followed with keen personal interest almost of the sporting kind. Frankly the author points out that he does not know why all but a few twining plants need thin poles for support. He does not follow the convention of anonymity, but is ever present, consciously, humanly, honestly, unobtrusively. He writes very much as though he were talking in his own greenhouse to a young friend. This reflects his device of trying to imagine someone present when he wrote, someone to whom he had to make his meaning clear.

Though the object of the book seems quite simply limited to describing plant movement, the points of contact with evolutionary ideas are lightly touched. There is, for instance, the non-classifiable *Corydalis claviculata,* of which Darwin says,[3] "This plant is interesting from being

[1] "Climbing Plants," p. 2. [2] *Ibid.,* p. 41. [3] *Ibid.,* p. 77.

"NATURAL SELECTION"

A cartoon of Charles Darwin, published in *Vanity Fair* on September 30, 1871.

in a position so exactly intermediate between a leaf-climber and a tendril-bearer, that it might have been described under either head," and he concludes, like Goethe,[4] "There can be no doubt that the tendril is a modified flower-peduncle." Again, as illustrating the unified view he took of all parts of nature, he tells[5] of one species whose "whole terminal portion exhibits a singular habit, which in an animal would be called an instinct; for it continually searches for any little crevice or hole into which to insert itself." The concluding remarks theorize on the question of how plants have developed these powers. Many, it seems, have some sensitiveness, which has been developed in some cases by natural selection.[6] "It has often been vaguely asserted that plants are distinguished from animals by not having the power of movement. It should rather be said that plants acquire and display this power only when it is of some advantage to them."

From plants which move and climb, like animals, because it is of some advantage to them, Darwin proceeded to study those yet more aggressive plants that capture and devour insects. "During the summer of 1860," he begins, "I was surprised by finding how large a number of insects were caught by the leaves of the common sundew (*Drosera rotundifolia*) on a heath in Sussex. I had heard that insects were thus caught, but knew nothing further on the subject." So he proceeded to investigate in considerable detail. The result is a thorough-going study,* far more pretentious than the "Climbing Plants," intended for both the general reader and the professional botanist, the latter alone being expected to read the small-print sections to which the many detailed accounts of special experiments are relegated. The outcome of these investigations is a discovery that the action of the leaf-

[4] See "Metamorphoses," discussed above, Chapter VII.
[5] *Ibid.*, p. 95. [6] *Ibid.*, p. 206. * "Insectivorous Plants" (1875).

traps and digestive cells is started by the presence of nitrogenous foods even in unbelievably small quantities. Much information, based on a great number of experiments, is given. The major plan of presentation is to proceed from the known to the less known by natural stages; the famous sun-dew is taken first, and its obvious, gross reactions before its subtler chemical responses. This fills half the volume, the remainder being devoted to similar, though briefer, accounts of other genera of insect-eating plants. Smaller sections are organized with equal care and equally admitted intention. One constantly meets such finger-post phrases as the following: "We shall now turn to the 106 experiments on——" and this: [7] "After the above long but necessary description of the parts, we will turn to their uses." There are many summaries to round out and finish separate topics. Chapter XI is a general summary of the *Drosera rotundifolia*, actually repeating briefly all that has been given so far.

The naïve personal touches, which we have come to expect, are here in abundance, but perhaps quotation is no longer necessary. A curious application, showing Darwin's constant tendency to personalize, appears in his quaint treatment of numbers and quantities—ordinarily the most abstract of terms. He is telling of a test for the least quantity of nitrogenous solutions that would spring the leaf trap, and proceeds: [8] "A bit of blotting-paper, weighing 1/465 of a grain, was placed so as to rest on three glands together, and all three tentacles slowly curved inwards; each gland, therefore, supposing the weight to be distributed equally, could have been pressed on by only 1/1395 of a grain, or .0464 of a milligramme." Or this: [9] "My results (Drosera being responsive to 1/30,000,000 of a grain of NA_3 KO_3 in 2,187,500 parts of water) were for a long time incredible even to myself, and I anxiously sought for every source of error. The salt was in some cases weighed for me by a chemist in an

[7] "Insectivorous Plants," p. 404. [8] *Ibid.*, p. 27. [9] *Ibid.*, p. 170.

excellent balance, and fresh water was measured many times with care," and so on. The book is a record of much work done, often ingeniously, with very simple equipment, interesting to read if one skips the small print.

The next * was a fuller and more searching treatment of the question raised in the orchid book. It was there shown that certain flowers are adapted to be fertilized only with pollen brought by insects from flowers on other plants. Under the hypothesis of natural selection such adaptations could have developed only if cross-fertilization strengthens the next generation for their life-struggle. This book contains the results of long observation and of eleven years of special study of this question. Artificial mating of both kinds was tried, with the general result that on the whole "cross-fertilization proved to be beneficial and self-fertilization injurious." The book is a good-sized one, simply designed and composed in the matter-of-fact tone natural in a work on a special topic. Chapter I introduces the subject, the next five treat of certain genera, the VIIth, VIIIth, and IXth compare the two types of fertilization, the Xth and XIth discuss means by which it is brought about, and the XIIth presents the general results.

There is no long-winded introduction; the first paragraph in the book states the whole situation, and, unless the inevitable personal bits be regarded as such, there are no waste stretches. As usual there is much direct narrative—from which one judges the author's resourcefulness in devising the most varied tests—and the imagery is homely and simple. Thus he writes of a mother-plant, of sisters, half-brothers, cousins. He watches the contest of vegetation and reports which ones "beat" the others, and how badly, like a sport-writer for some popular newspaper. One self-fertilized plant, which proved unexpectedly victorious, was nicknamed "Hero"; its descendants

* "The Effects of Cross and Self-Fertilization in the Vegetable Kingdom" (1876).

were reared and they inherited the same unusual powers! As this continued for generations, he concluded [10] that Hero was "a new variant and transmitted to its offspring a peculiar constitution adapted for self-fertilization." Here he was close to that still unsolved mystery of evolution, the beginning of a new variation. The evolutionary vein is present, though not greatly worked. He has this to say [11] of the result: "It throws light on the origin of the two sexes, and on their separation or union in the same individual, and lastly on the whole subject of hybridism, which is one of the greatest obstacles to the general acceptance and progress of the great principle of evolution. . . ." "The advantages [12] derived from cross-fertilization throw a flood of light on most of the chief characteristics of flowers. We can thus understand their large size and bright colors. . . . By this means they are rendered conspicuous to insects." Here, as in other works, Darwin has a way of quietly piling up evidence, bit by bit, as though it were trifling, which is more effective and convincing than much emphatic assertion. He objects to theoretical evolutionists, such as Spencer, holding that there is "an [13] innate tendency in all beings to vary and to advance in organisation, independently of external agencies," since such an outcome is due to the action of the environment. "The [14] advantages of cross-fertilization do not follow from some mysterious virtue in the mere union of two distinct individuals, but from such individuals having been subjected during previous generations to different conditions. . . ." "We must not," he continues,[15] "allow this highly generalised view, or the analogy of chemical affinity, to conceal from us our ignorance. . . . And so it is with many other facts, which are so obscure that we stand in awe before the mystery of life."

[10] "The Effects of Cross and Self-Fertilization," p. 50.
[11] *Ibid.*, p. 27. [12] *Ibid.*, p. 372. [13] *Ibid.*, p. 451.
[14] *Ibid.*, p. 443. [15] *Ibid.*, p. 457.

One such obscure fact was the existence of plants which bear flowers of two or three different kinds. This had been seen in his study of cross-fertilization, which process is aided by such differences. So his next book, based on a series of papers for the Linnean Society, treated "The Different Forms of Flowers on Plants of the Same Species." * This is, on the whole, his least interesting book, yet it shows the same qualities as the others if only in less marked degree. He makes a three-fold classification of the plants studied, and constructs the book accordingly. There are the familiar, genial trifles, the personal narratives which he regularly used. "It has long been known to botanists," he begins, "that the common Cowslip (*Primula veris,* etc.) exists under two forms. . . . Village [16] children notice this difference, as they can best make necklaces by threading and slipping the corollas of the long-styled flowers into one another." "We have [17] here a case to which no parallel exists in the vegetable, or indeed, in the animal kingdom. The individual plants of the present species . . . are divided into sets or bodies, which cannot be called distinct sexes, for both are hermaphrodites; yet they are to a certain extent sexually distinct, for they require reciprocal union for perfect fertility." What he calls "illegitimate unions" result in lessened fertility in the descendants, a sort of "hybrids [18] formed within the limits of one and the same species. This conclusion is important, for we thus learn that the difficulty in sexually uniting two organic forms and the sterility of their offspring, afford no sure criterion of specific distinctness," such weakness in mixed matings being dependent upon the "incompatible nature of their sexual elements, and not on any general difference in constitution." Considering the complexities of the subject, his exposition is little less than a triumph of clarity.

* (1877.)
[16] "Different Forms of Flowers," p. 5.
[17] *Ibid.,* p. 28.
[18] *Ibid.,* p. 242.

His next book, the last of the botanical series, is also the most complete and well-rounded. It is an outgrowth of the earlier work on climbing plants, a general treatment of "The Power of Movement in Plants." [19] The Introduction begins directly by explaining the spiral stretching "circumnutation" in visual terms, and proceeds [20] "Every growing part of every plant is continually circumnutating, though often on a small scale. Even the stems of seedlings before they have broken through the ground, as well as their buried radicles, circumnutate, as far as the pressure of the surrounding earth permits. In this universally present movement we have the basis or groundwork for the acquirement, according to the requirements of the plant, of the most diversified movements." The rest of the volume details those movements and their causes, through twelve chapters, first telling of seedlings, then of mature plants, then of certain special forms of motion, of lapses, of the effects of light and gravitation, of sensitiveness. It ends with a "Summary and Concluding Remarks." In spirit, atmosphere, style, it is quite like the rest of the series, so it may be left without further comment.

Toward the end of his life, Darwin turned once more to geology, his earliest scientific inamorata. He reissued in revised form the two early books of "Geological Observations on the Volcanic Islands and Parts of South America" (1876) written more than thirty years before and out of print, yet still in demand. The scientific papers written at about this time show a like return to some interest in invertebrates, a field in which several of his youthful successes were won. Quite late, he combined the two lines of study in a book on "The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits." * As long before as 1837 he had read a paper "On the Formation of Mould" before

[19] Assisted by Francis Darwin (1880).
[20] "Power of Movement," p. 3. * (1881.)

the Geological Society. Many tons of earth had passed through the intestines of worms since then, even on the twenty-odd acres attached to Down House, and innumerable observations had been made by Darwin and others. New discoveries in geology and anthropology had brought to light strange things long buried under worms' castings; old cities and ruined abbeys had been disinterred. So a new and completer study was in order.

This rather small and very human book attained a popular success that was "almost laughable." The first edition was snapped up at once; 8,500 copies were sold within three years. Reviewers were pleasant, for the author had won his accolade, and further because there was no dynamite in the present package. It is a gentle, genial book, rich in knowledge about a creature that all of us are more or less familiar with, in revelations both marvellous and convincing, rich, too, in pretty stories, in sights, sounds, and smells of the countryside. It opens wide vistas both in space and time and of another sort as well; that is, it reveals the variety and interest and *personality* in things which are usually not seen because they are too small and insignificant to be regarded. Under Darwin's rehabilitation, "the[21] earthworm steps forth at once as an intelligent and beneficent personage, a worker of vast geological changes, a planer down of mountain sides . . . a friend of man . . . and an ally of the Society for the preservation of ancient monuments."

Such, then, were Darwin's books. Besides these, he wrote some seventy-two scientific papers and a vast number of letters, for he was faithful in correspondence even to the answering of unauthorized inquiries from total strangers. He did not make speeches nor deliver lectures. Many of the papers were either advance sketches for his books or addenda and footnotes to them. Though naturally more technical than the books, because in-

[21] From a review. See Dorsey, p. 227.

tended only for his colleagues, the Fellows of the Linnean or such societies, in essence they are vital just as his books are, because of his instinct to seek the significant core of whatever he touched, so that for practical purposes we may regard them as mere accessories to the books he wrote, the real body of his literary work.

He continued active as long as he lived. The day before he died—April 19, 1882—a paper with a preliminary notice by Charles Darwin was read before the Zoölogical Society.[22] He faced death bravely and cheerfully, only regretting the trouble his illnesses caused others. Feeling his life to have been in some small way a successful one, he was happy despite much suffering. Many honors and awards came to him in old age, the most surprising one in death, for he—who had been and still is often accused of attacking religion—was buried with full High Church ceremony and canonical authorization in Westminster Abbey.

As a scientist his place in history is secure. His thousand little discoveries may slip away into obscurity, but he must be remembered as the first man to give a rational explanation of the origin of the species of living things, worked out clearly enough and sufficiently grounded in fact to win the adherence of most naturalists. There have been bitter controversies since 1859, many of them raging round the relative importance of natural selection and the Lamarckian factors of the direct influence of the environment, inheritance of acquired characteristics, purposeful adaptation, and so on. It has become the fashion among a certain group[23] of biologists to belittle Darwinism, or at least extreme Neo-Darwinism, in favor of the system of Lamarck. We need not try to adjudicate

[22] An essay on "Instinct" appeared posthumously as an Appendix to Romanes, "Mental Evolution in Animals," 1885.

[23] See, for instance, "Galatea, or the Future of Darwinism," by W. Russel Brain, in the "Today and Tomorrow Series" (1928).

this delicate scientific question. Suffice it to say that Lamarck's writings did not win the biological world over to evolutionary views while those of Darwin did. Whatever form the theory may eventually take, his name must be identified with it as that of Columbus is identified with the discovery of America.

It may be that his success was largely due to his greater ability to express his thought clearly, convincingly, winningly, vitally. He was not, like Huxley, a skilled and brilliant rhetorician, nor like Hudson or Burroughs primarily a literary man with some scientific leanings. He was thoroughly and whole-heartedly a man of science who wrote only because that was the one way of getting his ideas into other peoples' minds, who wrote with care and employed conscious literary devices because he could thus induce more people to read and absorb what he had to convey. Beyond this, there is a certain flavor, character, and charm to his writings, of which he was probably quite unconscious, as it was the mere aura of his own personality which he had simply not banished by stilted writing.

By his own testimony he found writing a difficult and perplexing art, which he mastered by following the local proverb that "It's dogged as does it." "There seems to be a sort of fatality," he says,[24] "in my mind leading me to put at first my statement or proposition in a wrong or awkward form." Even late in life he complained, "I have as much difficulty as ever in expressing myself clearly and concisely . . . but it has the compensating advantage of forcing me to think long and intently about every sentence, and thus I have been led to see errors in reasoning and in my observations or those of others." He thus attributed his success in writing largely to the hard work he put into it. This view is labored to the maximum by Dr. Dorsey, who entitles one chapter of his

[24] "Autobiography," p. 80.

biography [25] "He had to Learn to Write." According to this theory, motivated by pride in his work, "he did learn to write clearly and concisely, as he learned to read German, by hammering away at it."

This explanation is no doubt correct if one emphasizes the two words *clearly* and *concisely*. It is altogether misleading if one takes it to mean that he wrote wretchedly when young and by means of dogged effort came to write better and better as he grew older. His first book, the "Journal of Researches," is in some ways his best, but this was the result of chance. A narrative of travel in strange lands offers romantic possibilities not found in a study, for example, of the fertilization of a few genera of flowers. That first book does show, to the probing eye, some of the top-heaviness characteristic of the young author, a certain diffuseness, and (compared with the extreme plainness of his later works) a little tendency to be pompous. These faults are not marked, and the later elimination of them is not remarkable; there is no such contrast as that between the poorest and the best stories of Edgar Allan Poe. The "Journal" is a great, fascinating, artistically written book, and so is the "Origin" and so is the "worm book," but there is a difference. These three mark steps in a progressive simplification.

Some light can be obtained by glancing at Darwin's other early books—his "Geological Observations," for instance. In these technical reports there are passages as lively or as charming as anything in scientific literature, but there are lumps of avoidable technicality, suggesting the young naturalist who feels pleasure in the flavor and the trappings of his calling. The growth of his skill, then, was entirely along the line of writing more clearly and more concisely, and the growth was not spectacular.

In one other way, though this appears from his life and

[25] "Evolution of Charles Darwin," Chapter XIII, p. 249.

not from the books themselves, his literary ability grew. He worked far faster in old age than before. It took him ten years to work up all his "*Beagle*" material, eight for the "Cirripedia," twenty for the "Origin," whereas in later life scarcely a year passed without some volume appearing. This was due partly to his taking smaller subjects, partly to the fact that long investigations, begun during the long, lean years, came to fruition together or in swift succession. Yet, above all, it was due to his development of a technique. He outlined it thus: "I found that it saves time to scribble in a vile hand whole pages as quickly as I possibly can, contracting half the words; and then correct deliberately." He thus worked fast when creating and did the greater work of clarifying when revising. Often he followed the uneconomic practice of rewriting by correcting the proofs. At this stage he worked hard, even angrily or desperately, and got all the advice he could from friends. Even this did not add a new ability to work fast; we have seen how swiftly he wrote the early sketch and the essay on evolution. What he learned to do was to work regularly in this way which at first was accidental. His aim in revision was always to make the argument quite closely knit and the language so clear that it could not possibly be misunderstood. It was over this that he slaved and fretted, at this that he worked hard, at this actual writing and not at learning to write. "God knows," he declared, "I have never shirked a difficulty." The difficulty of writing was faced and met, and the fatality that led to awkward phrasing was gloriously overcome.

The good structure of his works was not accidental. He has described the method. "I spend a good deal of time over the general arrangement of the matter. I first make the rudest outline in two or three pages, and then a larger one in several pages, a few words or one word standing for a whole discussion or series of facts. Each

one of these headings is again enlarged and often transferred before I begin to write *in extenso*."

Clearness was his great aim. Once he advised a young man to "strike out every word which is not quite necessary to the current subject and which could not interest a stranger. . . . I think too much pains cannot be taken in making the style transparently clear and throwing eloquence to the dogs."

Apart from the constant struggle to be truthful and clear, his literary qualities seem to have been inborn, partly unconscious, indefinable. Some were the mere expression of his personality. "His style," said his son, Francis Darwin,[26] "has been much praised. It is, above all things, direct and clear, and it is characteristic of himself in its simplicity, bordering on naïveté, and in its absence of pretence." There is such a thing as honesty in style, and it is here. Also there is a plain homeliness in his books that is most engaging. Much of his writing can be visualized, and complex trains of thought become thereby easier to grasp. His books are rich in unobtrusive personal touches and in local color or imaginable background. There is little technicality, yet none of the sentimentalism that some popularizers substitute for it. "He could not help personifying natural things," [27] a method helpful to the reader and, so long as the personification is never more than a figure of speech, not unscientific.

The structure of his works has been seen as the product of care. It is often logical—inductive or, rarely, deductive. Much narrative gives variety and brightness to it. The method of experiment, the narration of the investigator's own tests and observations, is often employed, especially in his botanical works. All his later books frequently summarize at strategic points in the development. For example, Chapter XIX of "Variation under

[26] "Life and Letters," p. 131. [27] *Ibid.*, p. 95.

Domestication" is entirely given up to a summary of the preceding four chapters.

Of course, his greatness was basically a matter of the intellectual substance of his works, and it was here that his honest and dogged thrashing out of every topic weighed most significantly. He always gave worth-while ideas, based on facts and logical reasoning, organized in well-rounded, complete systems of thought. Above all, he never mistook phrases for realities, and though he sometimes handled the smallest matters, his approach was such that there is nothing pretty, trifling, or lacking in significance. Perhaps his greatest gift was a beagle-like instinct for the essence and value of each thing in nature.

An ingenuity in debate, not accompanied by any aggressive or combative tendencies, was one of his greatest assets. His knowledge was wide, and in his writings, at least, flows readily. This may have been due to his system of keeping from thirty to forty large portfolios, into which he put notes of every fact relevant to the subjects of study—to his indexing of all books read and summarizing of all books borrowed. The facts collected on any subject during a lifetime were all at hand in one portfolio. His habits of work and thought were methodical, so that when he had to prove a certain point, he had all the material needed, often much more, systematically arranged, built up into a mounting mass of evidence. Yet he never ranted. "The expressed inferences [28] in Mr. Darwin's works are few; he piles instance on instance and experiment on experiment, and almost invariably the conclusion to which he comes seems but the expression of the careful and unbiased reader's own thought."

Besides this, one sees the man in the work and likes the work because it reveals a lovable man. Despite his chal-

[28] G. W. Bacon, "The Life of Charles Darwin with British Opinion on Evolution," 1882.

lenging the world with a theory that was merely his own, despite his frequent use of the pronoun "I", he was modest—obviously, sincerely modest, almost humble. Thus he writes to a friend: [29] "Anyone as ignorant as I, if he could be found——" To Lyell, who had sent thanks that the "Origin" had been dedicated to him, he wrote, "Your note pleased me more than I dare say my dedication did you."

This was no pose. He never posed, for candor was one of his chief qualities. He hated a lie in any form; even a tiny, chance remark that might have given someone a false impression would worry his conscience and keep him awake until he had rectified the error. In his works, he ordinarily gives the arguments opposed to the view he is defending, gives them quite fairly, not as straw men set up to be knocked down but as views to be considered by reader and author in unison and then either accepted or turned down, not because he says so but on the evidence. This is not only a fair method but an interesting one. "The [30] reader feels like a friend who is being talked to by a courteous gentleman, not like a pupil being lectured by a professor" or harangued by a politician. His frankness is that of a courteous gentleman, of whom honor demands that he take no unfair advantage in order to win his point. So Darwin points out the loop-holes in his own work, does not stint saying, "I do not know," admits,[31] "I do not pretend that I should ever have suspected how poor was the record in the best preserved geological sections, had not the absence of innumerable transitional links between the species which lived at the commencement and close of each formation, pressed so hardly on my theory."

His dealings with Wallace and the question of priority have shown him in life the perfect mid-Victorian gentle-

[29] "Life and Letters, pp. 307-308.
[30] "*Ibid.*, p. 132. [31] "Origin," p. 441.

man, quite the antithesis of the current image of a genius, uncouth, egoistic, assertive, ruthless. Instead he, whose concept of a struggle for existence has led to the idea of a superman triumphing by the crushing of others, was essentially gentle and kindly. This, too, is evident in his work. His love of dogs and birds, his sociable, instinctive understanding of savages, animals, and even plants appears often in his books. It was a product of his immense sympathy with living things—a sympathy that made him fight against slavery [32] and the injustices of primogeniture. It was this sympathy that humanized any subject he touched, so that his most purely informative writings become a recreation of experience and are thus works of literary art.

There is a touch of simple humanity, too, in his homely misuse of English grammar. He sometimes writes *without* for *unless* as *"They die without they change,"* [33] uses the dangling participial phrase, *was* for *were* in the subjunctive (as "If there [34] was much more reason to admit"). He writes *notorious* for *well-known* as in this case [35] "It is notorious . . . that increased use or action strengthens muscles." He writes *"between each* successive formation," [36] "self-fertilizes itself," [37] "Nothing hardly astounded me more," [38] "to experimentise," [39] and so on. Such lapses, punishable in a freshman's theme, may actually be an advantage in these works of science. Certainly they do help to show us the man behind the book, and so help us to share his experience, not stopping at the information he conveys.

He is thus, par excellence, the creator of great works of science, some of which were also great because of purely literary qualities. Today, when progress has made

[32] "Journal." Also "Life and Letters," p. 310*ff.*
[33] 1844, "Essay."
[34] "Life and Letters," p. 433.
[35] "Variation under Domestication," Vol. II, p. 356.
[36] "Origin," p. 419.
[37] *Ibid.*, p. 97.
[38] "Life and Letters," p. 308.
[39] *Ibid.*, p. 443.

revision of some of his theories a necessity, his books can still be read, by persons of intellectual alertness though of no specialized training, with understanding and pleasure, especially with that rare sense of revelation that comes from seeing truth in the process of discovery, from being led by a thinker, who is also a human, vital, sympathetic man, into new and significant realms of thought.

CHAPTER XVIII

GLADIATOR-GENERAL AND MAID-OF-ALL WORK

Thomas Henry Huxley (1825-1895)

It has been seen that a large element in the tremendous influence of Darwin's ideas was the loyal and unstinted support given freely by certain friends, notably by Huxley. That fighter's activity in the cause was such that he came to identify himself with it utterly, to draw to himself much of the wrath that would seem more properly the share of the inventor of evolutionary doctrines. He called himself "Darwin's bulldog," "gladiator-general and maid of all work" for science, and even added some tang to Darwin's milder epithet of "general agent" by dubbing himself "general agent for the promulgation of damnable heresies." This was late in life when his pugnacity had not only earned him a reputation but had actually been accepted as his characteristic and therefore was generally forgiven. Some of his works have been outlined above because of their relation to the career of Darwin; but Huxley was a strong man in his own right as well, a powerful advocate, scientist of breadth and originality, perhaps the very greatest writer upon scientific subjects that the world has ever known.

His early life in some ways paralleled that of Darwin strikingly, in other ways as strikingly differed. He was the son of humble parents, his father a poor schoolmaster who left him nothing save a hot temper and an ability to draw, his mother a woman of swift, keen mind and of delicately balanced sensibilities such as marked her son also. His boyhood was spent in what he later called "a pandemonium of a school," and after an apprenticeship

with a medical relative, he was entered in the Charing Cross School of Medicine, London,—this despite his own inmost desire to become a mechanical engineer. Upon graduation, a stroke of wholly unconventional audacity got him into the staff of a naval hospital and after a few months of service into the crew of H.M.S. *Rattlesnake*. He travelled as assistant surgeon and naturalist. He took but slight and steadily decreasing interest in medicine "as the art of healing," but a passion began to grow in him to work out "the wonderful unity of plan in the thousands and thousands of diverse living constructions," to grasp the principles of physiology, "the architectural [1] and engineering part of the business" of a naturalist.

Before completing his medical course he had already made a discovery—of a hitherto undescribed layer in the human hair—and had written and published a paper about it. During the voyage, which lasted from 1846 to 1850 and included visits often lasting for months to the savage coasts of New Guinea, Huxley collected assiduously, and "sent home communication after communication to the 'Linnean Society,' with the same result as that obtained by Noah when he sent the raven out of his ark." In 1849 he drew up a more elaborate paper, "On the Anatomy and Affinities of the Family of the Medusæ." The tropical seas through which the expedition sounded afforded many strange species of this family of sea-creatures, some of them never before described. Edward Forbes, a leader in the field, declared that "More important or more complete zoölogical researches have never been conducted during any voyage of discovery in the southern hemisphere." He also praised the care and skill with which the young naturalist had dissected and examined "the impreservable creatures and . . . those orders of the animal kingdom respecting which we have least information . . . since thereby they fill up

[1] "Autobiography."

gaps in our knowledge." On the basis of these researches, Huxley made an important generalization of the greatest use to those who wanted to understand the place in nature of the jellyfish group. With typical bravado, he forwarded it to the Royal Society, though he was no Fellow and had no introduction, and awaited results.

No response was forthcoming until the voyage ended and he returned to England. The monograph had been published, separate copies being printed for the author's own distribution. He was soon admitted to the inner circle of the society, and two years later received the society's medal—all in recognition of the same piece of work.

Nevertheless he had no livelihood. This was the more serious as he had been engaged to a Miss Henrietta Heathorn ever since the *Rattlesnake's* visit to Australia where he had met her. He tried unsuccessfully to obtain professorships in Toronto and in other places. He had now given up medicine definitely for research in physiology. The Admiralty could not be persuaded to pay for the publication of the writings based upon his voyage, and eventually he left the government service altogether.

In 1854 an opportunity offered. Professor Forbes retired from the posts of Lecturer on Natural History of the School of Mines and Curator of Palæontological Collections in the Museum of Practical Geology, on Jermyn Street, London. Huxley was invited to fill these places. Neither gave the opportunity for physiological work that he really wanted, but he accepted the lecturership provisionally. He held the position for thirty-one years, and incidentally, though he "did not care for fossils," did a great deal of palæontological work. In 1855 he married.

He always professed to have no ambition, but by ambition he evidently meant desire for material success. "I assure you," he wrote his sister three weeks after the return to England, "I would not give two straws for all

the honours and titles in the world. A worker I must always be—it is my nature—but if I had £400 a year I would never let my name appear to anything I did or shall ever do. It would be glorious to be a voice working in secret and free from all those personal motives that have actuated the best." And again, "My demon says work! work! you shall not even love unless you work."[3]

Later he filled other positions of importance, though without giving up his professorship. Thus for six years (1863-1869) he was Hunterian Professor at the Royal College of Surgeons and for four years Fullerian Professor at the Royal Institution (1863-1867). These chairs gave their occupant the chance he had always wanted—to lecture on physiology. During 1860 he founded *The Natural History Review,* which he edited for a time.

His literary life may be sharply divided into two definite periods, the dividing line being the appearance of Darwin's "Origin of Species." Before that time he was distinctly and primarily the naturalist with physiological leanings. After 1859, while not withdrawing from that field, he became more and more the publicist, reaching the wide non-scientific public with popularized versions of evolutionary and other advanced theories, and in general setting himself up as the champion of liberal thought in all its many applications. His writings reflect this double character. His undergraduate paper on the human hair was so badly written, he tells us, that his professor had to correct its numerous slovenly lapses. "At that time," declares he in the "Autobiography," "and for many years afterwards, I detested the trouble of writing, and would take no pains over it"; and "I believe I had every fault a speaker could have (except talking at random or indulging in rhetoric), when I spoke to the first important audience I ever addressed, on a Friday evening at the

[3] Letter to Miss Heathorn, Nov. 13, 1852. See "Life and Letters."

Royal Institution, in 1852." Throughout the first period of his career, his interest lay in "the mechanical engineering of living machines." He spoke or wrote of these as an unpleasant necessity only, with no thought that his work might prove of general interest to readers, other than physiologists—or perhaps other naturalists—and certainly with no sort of notion that it might ever be classed as literature.

A glance at some of the titles may prove illuminating. Thus in 1853 his treatise on "Cephalous Mollusca" was published in the *Philosophical Transactions,* as the Royal Society calls its older and more important journal. In 1854 he gave the world a monograph on "Brachiopoda." After a visit to the Alps with his friend, John Tyndall, he collaborated in the "Observations on Glaciers," which appeared in the 1857 volume of *Philosophical Transactions.* His "Aphis" appeared in 1858, his large and thorough work, "The Ocean Hydrozoa," in 1859, published and authorized by the Ray Society. It will be noticed that none of the essays or general addresses for which he is now most famous were written before that momentous year of 1859. Still, lest we drop into the facile error of supposing that a technician without literary gift was suddenly converted by the revelation of natural selection into a consummate literary artist, it is to be noted that his early letters show a degree of care and of literary taste that surely bespeak a decided talent. Note, too, that even in his own modest description of his faults as a speaker, he specifically excepts talking at random and indulging in rhetoric. Simplicity, directness, perfect clarity were to be the outstanding qualities of his best later work; these virtues were not missing from even his otherwise unapt first public address.

It would be equally misleading to suppose that his technical work suddenly and completely ended when his newer work began. In fact his authority to defend far-

flung theories had its roots in the constantly repeated evidence of his wide and deep learning. So the technical communications continued, though they occupied a smaller place in his activity. In 1860 he issued a study of "Pyrosoma," in 1877 a manual on "Invertebrata," and in 1878 a treatise on "Crayfishes." During the two years of 1868-1870 he prepared a classification of "Birds and Dinosauria." He wrote the "Encyclopedia Britannica" article on "Amphibia" (1875) and in 1876 an essay "On Ceratodus." In 1858 he delivered the Croonian Lecture before the Royal Society. For this occasion he chose to speak "On the Theory of the Vertebrate Skull," definitely demolishing Oken's somewhat mystical doctrine that the skull is merely a modified part of the spine. "Huxley's Scientific Memoirs," were collected and republished in four volumes by Sir Michael Foster and his younger friend and colleague, E. Ray Lankester, in 1898, with a supplementary volume in 1903.

It is important that we realize the extent and quality of his purely scientific output, so as to avoid misunderstanding his sobriquet of the world's greatest popularizer. Most of the discussion here will be based upon books other than those already listed, but let it always be remembered that those popular or even political works were produced by a man who would have been distinguished as a discoverer and savant had the latter never been written. Of course he does not belong in the front rank with such originators as Newton, Copernicus, or Darwin, in the opinion of other scientists, who alone are the fit judges in this case; but some have accorded him a high place. Haeckel said [3] that his work on vertebrates "could be compared with the otherwise incomparable investigations of Carl Gegenbaur," and Sir Michael Foster and Professor E. Ray Lankester pronounce him to be "in some respects the most original and most fertile in dis-

[3] Both quotations are given as in Walker's "Lit. Victorian Era."

covery of all his fellow-workers in the same branch of science."

That these opinions are more than the isolated guesses of individuals is shown by his having been chosen President of the Royal Society for the Advancement of Natural Knowledge, that most esoteric chapter of the priests of science, as well as President of the Geological Society and of the Zoölogical Society. His definite contributions to knowledge may be summarized as follows:[4] 1. The discovery in undergraduate days of "Huxley's layer" in the human hair; 2. His work on the medusæ, showing how the jellyfish are constructed of two "foundation-membranes" and that the embryos of all vertebrate animals pass through the medusa stage; 3. His recognition, in "The Cell Theory" (1853), that it is the protoplasm within a cell and not the cell as such that is the real basic element of all life; 4. His prediction that "missing links" would be found to complete the evolutionary pedigree of the horse, definite indications of the kind of links to be expected, which—marvellously enough, to the popular eye—were all confirmed by the later discoveries of Professor O. C. Marsh; 5. His overturning, as related above, of the vertebrate theory of the skull. If any other proof were needed, it would be found in the eagerness with which Darwin awaited Huxley's verdict on the "Origin of Species"; if Lyell, Hooker, and Huxley approved it, he would feel that no amount of abuse from others could destroy his own faith in his work.

By way of sample, let us consider his short paper entitled "Further Evidence of the Affinity between the Dinosaurian Reptiles and Birds," which was published in 1870 in *The Quarterly Journal of the Geological Society*. This is not one of the early papers, but it shares with those the purely technical character. Like them it

[4] See Introduction to "Selections from Huxley," edited by C. A. Smith.

was written for colleagues, not for the general public. Furthermore, it is a sort of sequel to another communication. For all this, it is not without interest even for one with little anatomical preparation. Underlying it there is the feeling that its author is arguing one of the innumerable points which together make up the great case for evolution. If reptiles show affinities with birds, this adds one more to the instances in which evolution may have taken place. A large portion of the article is an anatomical comparison of the two types, tending to show that the *megalosaurus* had a huge clavicle and scapula, more like a bird's—as, for instance, the primitive, wingless *apteryx*—than any other creature's. The work of Professor Cope, as reported to the Philadelphia Academy of Sciences in 1868, is cited in confirmation.

Considered as writing, this article exhibits two noteworthy elements: it is admittedly very conjectural, and the author frankly presents the problem and shows his own efforts in the solving of it. In other words, even this purely technical paper is framed by the constructive imagination, and the writer does not disdain showing himself in his work. To some small extent, then, it enables the reader to realize the investigator's experience, and so to that extent it approaches literature. Futile as it is to look for an artistic character here where none was intended or thought in order, one should recognize that the man who wrote this was one who could turn his pen to such matters and some of his abounding talent flowed over into other fields.

Of this type, then, literary in slight degree, and only in spots as if by accident, was the production of Huxley's early period. The first force tending to make him study the methods of expression was his appointment in 1854 to the lecturership. He had indeed spoken in public before that, but infrequently and faultily; now one of the duties of the government lecturer was to deliver a course

of six lectures biennially to audiences of workmen. It became not only his duty but an imperative necessity for him to speak with simplicity and attractiveness sufficient to captivate an audience very largely unprepared for the sort of topics that he would expound. He deliberately set to work to cultivate the right sort of style. As to the style he aimed at creating he was quite definite and clear. His ideal was to "say that which has to be said in such language that you can stand cross-examination on each word." A rationalist by nature and conviction, he found addressing "these hard-handed fellows who live among facts" quite in keeping with his own realistic view of things. To him "the saying exactly what he meant, neither too much nor too little," [5] was a moral as well as a literary ideal. It is not honest, not straightforward nor truthful to express yourself equivocally, even if the ambiguity is unintentional. "Be clear, though you may be convicted of error. If you are clearly wrong, you will run up against a fact some time and get set right. If you shuffle with your subject, and study chiefly to use language which will give a loophole of escape either way, there is no hope for you. This" declares his son, Leonard Huxley, "was the secret of his lucidity." Other literary qualities as well as lucidity came to enrich the essays that he wrote, but it was this, first and last, that he aimed at.

He had doubted the transformist hypothesis when he talked it over with Darwin in the early fifties. At that time he knew "nobody but Dr. Grant," [6] of University College, who had a word to say for Evolution, and his advo-

[5] Quoted by C. A. Smith.

[6] Quoted from "On the Reception of the Origin of Species." Robert Edmond Grant, M.D., Professor of Comparative Anatomy and Zoölogy. His "Essay on the Study of the Animal Kingdom," 1828, traces the animal kingdom backward and shows "many extraordinary analogies, . . . enquiries into the origin and duration of entire species . . . and the changes they undergo by the influence of climate, domestication, and other external circumstances."

cacy was not calculated to advance the cause." There was also Herbert Spencer, but neither of these could make the subject convincing or alive. We have seen how swiftly and courageously Huxley ranged himself on the adventurous side in the struggle which he was the first to foresee, how he defended evolution by careful study or, when the situation demanded it, by argument, sarcasm, and personal ridicule. The appearance of the "Origin" jibed perfectly with the great purpose and desire of his own life; by the aid of its principles the "unity of plan in the thousands and thousands of diverse living constructions" could be more readily seen, and, above all, that unity became more than the curious set of coincidences it had always been, a logical and fascinating story full of intellectual thrills.

Once the first spasms of conflict were past, he settled down to what was to be his real life-work, the popularization—more properly the humanization—of the great scientific advance. Without ceasing his researches, he threw the weight of his activity into the new work of writing for the public. He was much in demand as a speaker; many of his essays show by form and diction the influence of the platform for which they were intended. Some were originally written for periodicals, and both kinds were collected from time to time into volumes, sometimes grouped according to fitness but sometimes collected into one volume merely because they would fill it. Even "Man's Place in Nature," [7] in some ways the completest of his better known works, is but a loose confederation of allied treatises. His volume on "Method and Results" is made up of "one [8] essay on the method of science and eight on certain results" achieved by scientific method in practice. "Evolution and Ethics" (1893) presents his scientific interpretation of right and wrong;

[7] See above. Chapter 15.
[8] Preface to "Method and Results."

but, as two moderately sized discussions of the subject—even with the more or less adventitious assistance of "Prolegomena" and Notes—cannot fill a volume, it is eked out with the author's letters to the *Times* on political and economic matters. "Darwiniana" contains his writings, of widely scattered periods, on Darwin and his discoveries. It includes his delightful short biography of Darwin. At some points, apparently, he gave up the attempt to group unrelated material together in some kind of reasonable order; one volume is called "Science and Culture" after the address which happens to come first in it, another simply "Discourses," as though no more specific name would fit the various contents. There is a volume of "Lay Sermons, Addresses, and Reviews" (1870), one of "American Addresses," containing the author's deliverances during his visit here in 1877 to help inaugurate Johns Hopkins University, but also containing some other speeches needed as ballast for an underweight volume. His many and bitter controversial essays were collected into two books, "Science and Hebrew Tradition" and "Science and Christian Tradition" (1893). Finally in 1894 he carefully went over his popular writings, preserving in the "Collected Essays" all that he cared to keep. It is therefore unprofitable as well as inconvenient to discuss his separate books separately, far more useful to look for the qualities which run more or less through them all.

First, then, we must note an almost fierce love of truth—a somewhat naïve, Victorian Liberal confidence that the truth could be found, that he had found it. Perhaps this came from his boyhood worship of Carlyle and the uncompromising rectitude of the old Scottish prophet. Perhaps it was an inborn and unescapable trait. At all events it dominated every bit of work that he did, lent a motive for his innumerable controversies, suggested the kind of style that was to be identified with the man.

Said he: [9] "If wife and child and name and fame were all lost to me, one after another, still I would not lie.... The longer I live, the more obvious it is to me that the most sacred act of a man's life is to say and to feel, 'I believe such and such to be true.' All the greatest rewards and all the heaviest penalties of existence cling about that act." He describes his aim in life in these words: [10] "To promote the increase of natural knowledge and to forward the application of scientific methods of investigation to all the problems of life to the best of my ability, in the conviction which has grown with my growth and strengthened with my strength, that there is no alleviation for the sufferings of mankind except veracity of thought and of action, and the resolute facing of the world as it is when the garment of make-believe by which pious hands have hidden its uglier features is stripped off."

This manifesto accounts for most of what he did in life. He was not unlike Dr. Stockman, in Ibsen's "An Enemy of the People," that childlike country doctor, who, discovering that the townsfolk wanted to suppress his discovery of disease germs in the water supply, made it his life-work to blare forth that there were disease germs in their spiritual life. Huxley, finding that the truth about scientific matters was suppressed on grounds that had nothing to do with its inherent probability, made it his business to attack everything that to him seemed to threaten the spread of truth. This terrific honesty is evident in a score of ways in addition to his own talking about it. The intense, unmistakable lucidity of his style is an outgrowth of it; he must write so that his very mistakes, if there were any, should be patent. When arguing one side of a dispute, as he most often is doing, he is sure to acknowledge, to point out, and insist upon the weak spots in his own brief with almost the same fervor

[9] and [10] "Autobiography."

and with quite the same distinctness that marks his showing up the weaknesses of the opponent. Thus, in discussing the descent of man,[11] he declares: "The structural differences which separate man from the gorilla and the chimpanzee are not so great as those which separate the gorilla from the lower apes. But in enunciating this important truth I must guard myself against a form of misunderstanding which is very prevalent . . . that the structural differences between man and even the higher apes are small and insignificant. Let me take this opportunity, then, of distinctly asserting, on the contrary, that they are great and significant, that every bone of a gorilla bears marks by which it might be distinguished from the corresponding bone of a man. . . . It would be no less wrong than absurd to deny the existence of this chasm." And elsewhere,[12] after describing the "Uhlans" of science, whose scientific imaginations are more active than thorough, he adds, for the remainder of the essay, "I deliberately take the shilling of the recruiting sergeant of the Light Brigade, and I warn all and sundry that such is the case."

Unlike many lovers of truth, he understood how to apply his general principle to each particular case. Both in natural knowledge and in expression, by means of language, he strove for absolute accuracy. Here and there it led him into more technicality than most readers like, but as a rule his love of clarity taught him to steer clear of the Scylla of technicality as well as of the Charybdis of inaccuracy. That he would go to considerable effort to secure an accurate view is evident from this incident: it is said [13] that he learned the Greek language at forty to see whether Aristotle, as some have maintained, had made the unconscionable blunder of supposing the heart to consist of three chambers, when the most primitive dis-

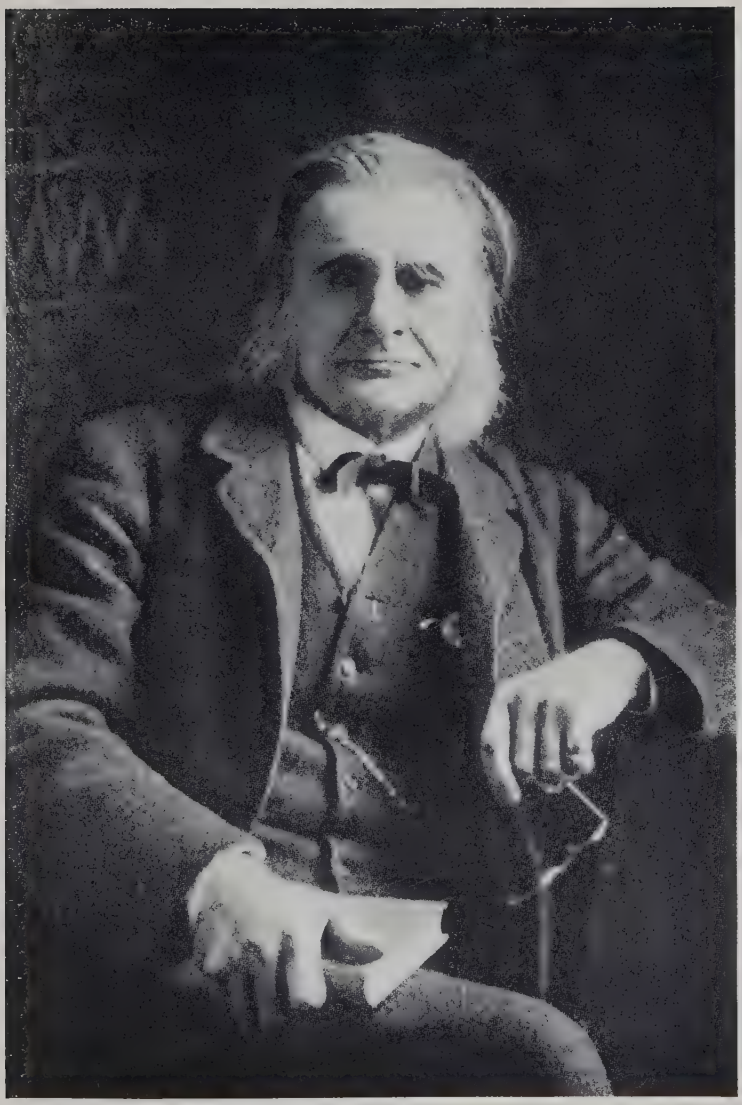
[11] "Man and the Lower Animals," p. 144, in "Man's Place in Nature."
[12] "The Aryan Question," p. 282.
[13] Ada S. F. Snell, "Selected Essays of Huxley's." Introduction.

section would have shown four. Huxley came to the conclusion that the faults were due to the translator's lack of physiological knowledge, and that the great Stagyrite's account "is true so far as it goes." [14]

Here one sees not only Huxley's love of accuracy but his rare cultural background, the breadth of which made him a formidable antagonist. He was able to subpœna all sorts of authorities, including those generally ranked on the other side, to prove his points. Such curiosities of scientific literature as Suarez, the Spanish Jesuit, St. Augustine, and Thomas Aquinas were cited by Huxley to his own purpose. Apart from the argumentative value, his scholarship had a literary use in the enrichment of background. Scarcely an essay of Huxley's is devoid of some classic or scriptural allusion quaintly used. "Thus," he writes,[15] after expounding what he has learned about chalk, "there is a writing upon the wall of cliffs at Cromer and whoso runs may read." He refers to "blind leaders of the blind," [16] to Aladdin's lamp, and Cinderella, to Homer's description of a starry night; he says "it is not alone those who pursue astronomy who ask for bread and receive ideas," "Ichabod! Ichabod! the glory will be departed from us." He refers to the picture by Retzsch showing Satan playing chess for a man's soul,[17] to Goethe's "ohne Hast, ohne Rast." In scores of places he alludes to English and foreign history, as when he speaks of "Nature having no Test-Acts."

The unusual wealth of such allusions to literature, art, philosophy, history, and politics bespeaks a mind broadly cultivated. It beautifies the essays and in some cases even helps toward advancing his constant ideal of accuracy and clearness by illustrating some otherwise obscure concept. The most noteworthy feature, though, is

[14] "Science and Culture."
[15] "On a Piece of Chalk."
[16] "Improving Natural Knowledge."
[17] "A Liberal Education."



THOMAS HENRY HUXLEY

the readiness with which the author takes these allusions in his stride, as it were, and quite incidentally.

Perhaps it is the very casualness with which his allusions and other stylistic graces are moulded into the substance of his work that made it seem to the author himself that his work was devoid of such idle adornment. In his "Autobiography" he laments that a swarm of bees had been prevented from settling upon his lips in infancy, for then he "should have been endowed with that mellifluous eloquence which, in this country, leads far more surely than worth, capacity, or honest work, to the highest places in church and state. But the opportunity was lost," he goes on, "and I have been obliged to content myself through life with saying what I mean in the plainest of plain language, than which, I suppose, there is no habit more ruinous to a man's prospects or advancement." His language was plain in the sense of having an unmistakable meaning; but if plain language means language unadorned and matter-of-fact, then Huxley was certainly gifted with "that mellifluous eloquence" which he decried. Perhaps, too, when he declared [18] that "gilding refined gold would be less objectionable than varnishing the fair face of truth with that pestilent cosmetic, rhetoric," he did not realize that that was just what he was even then doing. Not that his art concealed or falsified the truth; but he never stopped at merely saying clearly what was true. He said it as vividly, as strikingly, as wittily, and with as much charm as possible.

A thousand instances could be given of the high visualizability of his imagery. One [19] must suffice: " . . . Bethink you that these elephantine bones did veritably carry their owners about, and these great grinders crunch, in the dark woods of which the forest-bed is now the only trace. . . ." That he used every one of the usual figures

[18] "Science and Morals," p. 128. [19] "On a Piece of Chalk."

of speech is clear from instances already given. Here are some more: For the simile [20] "amongst these fading reminders of a previous state of things, are some very modern forms of life looking like Yankee peddlers among a tribe of Red Indians"; Personification: "Defoe shows death, with every accompaniment of pain and terror, stalking through the narrow streets of old London"; [21] Antithesis: " . . . How harmoniously the holy cursing of the Puritan of that day would have chimed with the unholy cursing and the crackling wit of the Rochesters and Sedleys . . . "; [22] Metaphor: "That man has had a liberal education . . . whose intellect is a clear, cold logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind"; [23] Irony: "All these terrible apparatus [induction and deduction] are being used by yourselves every day and every hour of your lives." [24] His ironical allusions of an incidental sort are many and fine. Thus, he compares the method of science to the reasoning used by a man who finds his spoons missing in the morning and concludes that a thief must have stolen them during the night. To sneer at those who explain natural matters by spiritual means, he asks: "How do you know that the laws of Nature are not suspended during the night? . . . some kind of supernatural interference" may have caused the spoons to disappear.

Of vituperation, ridicule, and other more or less ironic expressions of contempt and hostility, Huxley was past master. In attacking the Victorian emphasis upon classical education, he had this to say: [25] "It is wonderful how close a parallel to classical training could be made out of that palæontology to which I refer. In the first place, I could get up an osteological primer so arid, so pedantic

[20] "On a Piece of Chalk." [21] "Improving Natural Knowledge."
[22] *Ibid.* [23] "A Liberal Education."
[24] "Method of Scientific Investigation." [25] "A Liberal Education."

in its terminology, so altogether distasteful to the youthful mind, as to beat the recent famous production of the headmasters in all these excellences." He refers to [26] "that region where gentle (or ungentle) dulness so often holds sway—the pulpit"; he implies unkind judgments about simple faith in declaring [27] that "belief, in the scientific sense of the word, is a serious matter and needs strong foundations." This sort of comment gives ample scope for witty or clever or humorous phrases, of which several must have been evident.

Noticeable, likewise, is his love and frequent use of most racy diction, not merely that of belles lettres or of common speech—in contrast to the cold abstraction of some scientific writers—but words full of the savor and fragrance of the stable-yard, the market-place, or the public-house. He calls [28] the capitalist "a thief with a circumbendibus." He gives warning that all [29] "those who won't learn at all are plucked; and then you can't come up again. Nature's pluck means extermination." "The undulating downs have a peacefully domestic and mutton-suggesting prettiness. . . ." [30] "Or, to take a more familiar example, the fur on the inside of the tea-kettle is carbonate of lime; and, for anything chemistry tells us to the contrary, the chalk might be a kind of gigantic fur on the bottom of the earth-kettle, which is kept pretty hot below." "Let us fix our attention upon the *Globigerina*. It is the spoor of the game we are tracking."

Certainly he realized the value of using such diction as would convey not only a clear meaning but a vivid picture and an emotional stimulus. In "Science and Art," he quotes "one notable passage: 'The difference between

[26] "Science and Morals."
[27] "Biogenesis and Abiogenesis," in "Discourses, Biological or Geological."
[28] "Liberal Education." The insult is attributed to the pauper. "Pluck" is British slang for "flunk."
[29] *Ibid.*
[30] The next three quotations are from "A Piece of Chalk."

good and bad teaching mainly consists in this, whether the words used are really clothed with a meaning or not.' " This applies to writing as well as to teaching. "I remember," he continues, "in my youth there were detestable books which ought to have been burned by the hands of the common hangman, for they contained questions and answers to be learned by heart, of this sort, "What is a horse? The horse is termed *Equus caballus;* belongs to the class Mammalia; order, Pachydermata; family, Solidungula.' Was any human being wiser for learning that magic formula? Was he not more foolish, inasmuch as he was deluded into taking words for knowledge?"

The unwillingness to be deluded by taking words for knowledge determined not only the style of his writings but the whole tenor of his thinking. His fiery championship of evolution, his furious attacks upon theologians who wished either to deny the new learning altogether or to show that in some mysterious way it was implied in the old traditional beliefs, all grew out of his unwillingness to be thus self-deceived. As a boy he had studied Hamilton's "Philosophy of the Unconditioned," and this is his reaction: "It stamped on my mind the strong conviction that on even the most solemn and important of questions, men are apt to take cunning phrases for answers." This he meant never to do. Hume was therefore his favorite among the metaphysicians. He expressed this admiration in a practical way by writing the life of Hume, in 1876, for the "English Men of Letters" series. He found in the eighteenth century Scot a clear recognition that philosophy can be grasped best by studying the workings of the human mind, and that the mind can be best understood by scientific methods of investigation, not unlike those used in physiological experimentation.

This sounds much like what used to be condemned under the name of "materialism." Huxley was often called a materialist, furthermore, because of his definite idea

that life exists only in and through protoplasm. He made this doctrine temporarily notorious by his lecture, "On the Physical Basis of Life," delivered in Edinburgh, during the course of which he showed his hearers a bottle containing the chemicals that enter into protoplasm and telling them that the materials of life were all there, waiting to be combined. Yet he was in fact not altogether a materialist, for he maintained [31] that "the world contains matter, force, and consciousness . . . "; that, though consciousness can never express itself save upon matter and by means of force, it is something other than either of these two—something, which in the reasonable modesty instilled by scientific study, he confesses himself unable to explain. Consciousness needs an intermediary, the organs of sense, and it is the pictures these give of outer things that supply our only knowledge. "The nervous system [32] stands between consciousness and the assumed external world, as an interpreter who can talk with his fingers stands between a hidden speaker and a man who is stone deaf." If by "materialist" one means a seeker of his own material welfare regardless of moral considerations, a glimpse at Huxley's constant battle for the merely moral ideal of honesty, despite much exertion and some personal suffering, will be sufficient answer. Nor did he hold, with Nietzsche, that the battle should be to the strong, because under evolution so it is. He considers that social welfare demands resisting the struggle for existence.[33] "Ethical progress depends on combatting the cosmic process." Men should coöperate, not compete, under a state equally just and enlightened toward all. Even then there can never be a millennium, for a time must come when the weeds of nature will return to overwhelm the garden of civilization. The one hope is in education, for [34] "the intelligence which

[31] "Science and Morals." [33] "Ethics and Evolution."
[32] "Animal Automatism." [34] "Biological Sciences and Medicine."

has converted the brother of the wolf into the faithful guardian of the flock ought to be able to do something towards curbing the instincts of savagery in civilized men."

He did not regard the world as a fortuitous concourse of atoms, but as a cosmos. In some way, things make sense: the various sciences "are independent in proportion as they are imperfect; and it is only as they advance that the bonds that really unite them all become apparent." [85] "The state of Nature, at any time, is a temporary phase of a process of incessant change." Like Spencer, he saw a sort of system and method in the madness of the world. Again [86] he thinks "the optimistic dogma that this is the best of all possible worlds . . . little better than a libel upon possibility . . . however neither is it the worst world"; it is "neither moral nor immoral but non-moral," a sort of "materialized logical process." He thus was no unqualified materialist in his view of the universe any more than in his vision of the individual human being. He could not help thinking that even though [87] "material changes (i.e. in the brain) are the cause of psychical phenomena," they do not offer a complete explanation. The feeling of æsthetic pleasure, such as one's joy at sight of a beautiful sunset, is a super-material mystery. Some day it will be explained,[88] "but if ever that day arrives, the rapture will remain, just as it is now, outside and beyond the physical world, and even in the mental world, something superadded to mere sensation."

He could answer in the negative, likewise, to those who accused him of atheism. Though by no means one of the faithful, neither does he belong "among atheists, for," he declared, "the problem of an ultimate cause is . . . hopelessly out of reach of my poor powers." To describe his own creed, Huxley invented the now popular term

[85] "Evolution and Ethics."
[86] *Ibid.*
[87] "Science and Morals."
[88] *Ibid.*

agnostic—or one who does not know—deriving it from the name of an early sect of *gnostics* who felt that most assuredly they did know. On these great questions he admitted his ignorance, but like Darwin and Spencer, felt that the rest of the world knew no more than he. Unlike Darwin, however, he forced the issue of knowledge. Darwin stopped with admitting his own ignorance and evading any solution; Huxley admitted his own ignorance and insisted that all the most respectable believers were just as ignorant as he was and that their pretensions to knowledge were baseless and irrational. Much is heard in these days of what is called "scientific determinism"; it is used by many who have but a smattering of scientific knowledge as an excuse for any sort of conduct. Naturally Huxley was accused of fostering this anti-social doctrine. He was called a fatalist; this label he disowned, for he held that, within many natural restrictions, man does exercise choice. Men are therefore moral beings, accountable—as Nature rigidly holds them —for all their actions.

Some of his ethical ideas, however, were just the reverse of what is commonly approved. He had no good to say of obedience as such or of "knowing one's place" or of respecting authority. Experience and objective observation show us that man's welfare depends on the welfare of the State, which is enough motive for right conduct. People should think for themselves and speak the truth, and all will be well. "Veracity is the heart of morality." [39] "Few social evils are of greater magnitude than uninstructed and unchastened religious fanaticism; no habit more surely degrades the conscience and intellect than blind and unhesitating obedience to unlimited authority." [40] He has no sympathy for supernatural incentives to virtue, refers [41] with contempt to "the spirit

[39] "Universities Actual and Ideal."
[40] "Evolution and Ethics." [41] "Science and Morals."

which a man carries around under his hat." Man needs no promise of a future life; if you "do what you can to do what you ought," you may "leave hoping and fearing alone."

He has hard words to say for those who choose beliefs according to consequences rather than upon evidence—such as those who deny evolution because it may lead to infidelism.[42] "If the view I have taken did really and logically lead to fatalism, materialism, and atheism, I should profess myself a fatalist, materialist, and atheist," for "the only question any wise man can ask himself and which any honest man will ask himself is whether a doctrine is true or false. Consequences will take care of themselves." This religion of his is thus a common-sense reasoning based upon scientific learning, and nothing else. Revelation he completely discounts. "Natural knowledge seeking to satisfy natural wants, has found the ideas which can alone still spiritual cravings." [43]

The same realistic attitude dominates his educational theories. Education should be practical but never technical. It is an absurdity for the cultured man to know nothing about the great world of nature or about his own body or about work. Trades, however, can best be taught in the shop. Science, of course, is to constitute the nucleus of the curriculum, especial emphasis being laid upon human physiology and hygiene. The study of physical geography would do more than anything else to counteract mental provincialism. The use of English as an instrument of expression, a reasonable command of other living tongues (or of one such), and an ability to do simple drawing are very important. Precocity and overlearning are to be avoided, and mere pedantry, the conning of dead tongues and unrelated facts, should be fled as the pest. The method of teaching should always be vitalized by the fiery conviction that the pupil is learn-

[42] "Animal Automatism." [43] "Improving Natural Knowledge."

ing to *live,* not merely going through some sort of rote performance. "The great end of life is not knowledge, but action." [44] "The most valuable result of all education is the ability to do the thing you have to do, when it ought to be done, whether you like it or not." [45]

Like most really important educators he saw education as a process of growth in personality, not as a process of acquiring knowledge. He had some opportunity to put his ideas to the test while in charge of the South London Working-Men's College and during his membership in the London County Council. Of course he insisted on more science in education; but what puzzled and amazed many people was his insistence on the teaching of English literature and the Bible. Culture, he felt, was impossible without the former, and he saw no way in which "the religious feeling, which is the essential basis of conduct, was to be kept up, in the present utterly chaotic state of opinion, without the use of the Bible." Educational opportunities were to be free to all, regardless of social standing or wealth, or the lack of these desiderata; and girls were to have the same education as boys and the same opportunities in life as well, with none of the traditional limitations or special privileges.

His outspoken and challenging attitude on questions so intimately bound up with the dearest concerns of many people brought him into innumerable conflicts. Unlike Darwin, who borrowed from Lyell a determination never to reply to any controversial opponent—except on rare occasions when the mooted point was a definite matter of demonstrable scientific fact—Huxley was constantly and ardently disputing. Ever after his hugely triumphant battles at Oxford with Owen and Wilberforce, public disputation was his life-work, at least the more spectacular part of his life-work. Some of the essays

[44] "Technical Education." [45] *Ibid.*

already referred to were practically briefs in argument; the more thoroughly contentious of his writings are contained in the two sets, "Science and Hebrew Tradition," and "Science and Christian Tradition." These two books bring out his criticisms of the Old and New Testaments respectively, most of which were originally published periodically in reply to some writer of fundamentalistic views who had either denied evolution or had tried to "reconcile" it with Scripture.

He was, for instance, led into a series of bitter arguments (in the press, of course) with the noble Duke of Argyll.* That prominent aristocrat, politician, theologian, and naturalist took exception to some of the implications of evolutionary theory, in his very popular essay, "The Reign of Law." [46] The duke did not deny that evolution may have taken place; he sought to bind it directly to creation. "Whatever" [47] he declares, "may have been the method or process of Creation, it is Creation still. If it were proved tomorrow that the first man was 'born' from some pre-existing Form of Life, it would still be true that such a birth must have been, in every sense of the word, a new Creation." Evidently he knew a good deal about science, especially about birds, and had read widely in the biological libraries. He can cite Darwin to his purpose—to prove that organs are devices, implying that they were designed. He knows his Owen, too, and prefers that anatomist's Platonic idea of an archetype to any doctrine of real and physical descent. Above all, he and his allies [48] "revolt from the doctrine as applied to man. We do so because we are conscious of an amount and a kind of difference between ourselves and the lower animals, which is, in sober truth, immeasurable, in spite of the close affinities of bodily structure." In smooth, polished phrases, but with a worried over-eagerness for

* Lord George Douglas Campbell K.G., Eighth Duke of Argyll (1823-1900).

[46] 1867. 19th edition, 1890.

[47] *Ibid.*, p. 29.

[48] "Reign of Law," p. 264.

his cherished beliefs, the duke expounds these ideas of his, and he does not quarrel with Huxley and only indirectly with Darwin. His two other famous works, "Primeval Man, An Examination of Some Recent Speculations" (1869) and "Organic Evolution Cross-Examined, or Some Suggestions on the Great Secret of Biology" (1898), which repeat the same essential ideas as applied to man and to the whole of nature, directly attack Sir John Lubbock and Herbert Spencer respectively. Though admitting, like Huxley, that the Miltonic story of creation is "childish and grotesque," Argyll calls the term *natural selection* "an admirable phrase for giving a certain plausibility and vogue to a theory full of weaknesses not readily detected."

His real conflict with Huxley came about more incidentally. In 1887 that fighter had published an essay on "Scientific and Pseudo-scientific Realism" contrasting the so-called "realism" of the mediæval scholastics—actually a theory that ideas are the only realities—with the purely objective doctrine of science that natural law is no agent or cause but a mere record of events. The Duke of Argyll published an angry answer; and when Huxley's acid rejoinder, "Science and Pseudo-science," appeared the duke expressed himself upon that. Huxley's reply this time was combined with an answer to the Bishop of Carlisle, who had been preaching on "The Advance of Science"; he finds the bishop taking steps toward "bringing about an honourable modus vivendi," in contrast with the duke's attitude.

More frequent and more satisfactory from every viewpoint except that of the discovery of truth were Huxley's many sword-crossings with William Ewart Gladstone,* the grand old man of Victorian political liberalism. "The apparent inconsistencies of Gladstone's career arose from the fact that he was Conservative in sentiment but Liberal in opinion." ** Opinion ruled his political career, so

*(1809-1898.) ** "Nelson's Encyclopedia."

that most of the great advances in English democracy during the reign of Victoria are associated with his efforts. Sentiment, however, conservative sentiment, dominated his philosophy of life, permeated his religion. He was long estranged from his youthful friend, Cardinal Manning, when that Anglican divine took the road to Rome.[50] In like manner, though they lay at the opposite end of the metaphysical spectrum, the growth of new scientific ideas filled the old statesman with sorrow. During his periods of retirement, in the fifties, and the seventies, and from his last withdrawal in 1894 until his death, he occupied himself with assorted writings—on the Homeric age, on various religious questions (for instance, "The Vatican Decrees," in 1875), and with the philosophy underlying science. His most ambitious work is the volume entitled "The Impregnable Rock of Holy Scripture," which made its appearance in 1890. Of this book, Hugh Walker says [51] that it "is preserved from oblivion by the wit of Huxley's replies." A large share of the battle raged around the story of Jesus and the swine of Gadara which, we are told, being possessed by demons, were made to hurl themselves into the sea. Gladstone's book, originally published as a group of essays in "Good Words," strove to authenticate this miracle. Huxley, in two articles, tried to prove not only that demoniac possession is absurd but that a prophet who caused property-destruction on any such theory was not honest. Both controversialists were painfully courteous to each other, with that strange courtesy that is one of the marks of deep hostility. At last the *Nineteenth Century* closed its columns to both.

Before that they had come to clashes over the more appropriate topic of creation. The real trouble was started by one Albert Reville, a French Protestant the-

[50] See Strachey's "Eminent Victorians."
[51] "Lit. Vict. Era," p. 653.

ologian, professor of the history of religion at the College de France, who had written a "Prolegomènes a l'histoire des Religions." Now this was a volume of higher criticism which did not shrink from an audacious treatment of Scripture, pointing out, among other things, scientific errors in the biblical narrative. Gladstone wrote a review of this book, which was included in the 1885 volume of the *Nineteenth Century Magazine*. He called it "Dawn of Creation and Worship." [52] In that article the great Liberal tried his hardest to show that the alleged misstatements are scientifically "essentially" correct, after all, that Reville had written not a *pro-* but an *epi*-legomena "to a History of Religions not yet written." Huxley replied in a later issue of the same periodical with "The Interpreters of Genesis and the Interpreters of Nature," charging Gladstone with ignorance of science. In his rejoinder, "Proem to Genesis—a Plea for a Fair Trial," Gladstone, still polite but growing huffy, quoted the works of certain scientists to show that he was not so ignorant as Huxley supposed. But as might be expected, that "bull-dog" held on; in "Mr. Gladstone and Genesis" (1886) he returned to the combat, having the last—and best—word. Both men lashed out with increasing savagery, scarcely concealed, and to what now seems no good purpose. Gladstone was old but still lusty and certainly determined; Huxley was doing what he could do better than anyone else. Yet that detailed thrashing of empty questions seems today utterly irrelevant either to religion or to science. Some such criticism was made at the time, and Huxley answered that if the swine (in the Gadarene miracle) [53] "were the only parties to the suit, I for my part should admit the justice of the rebuke. But the real issue is whether the men of the nineteenth century are to adopt the demonology of the men of the first

[52] Included in "Gleanings of Past Years," Vol. VIII, p. 35*ff*.
[53] "Collected Essays," vol. V., p. 414.

century as divinely revealed truth, or to reject it as degrading falsity." After all, it was this campaign—a campaign to make the world safe for independent thought along rationalistic lines—that gradually became Huxley's major activity in life.

He had other controversies as well,[54] "numberless literary and scientific battles, and in not one did he fail. Whenever he crossed swords with an antagonist—Wilberforce, or Owen, or Gladstone—Huxley remained master of the field; and his manner of fighting the duel is a model which may be commended to the careful study of all who are minded to go and do likewise." He disputed with Dr. S. Wace and Prof. Laing on agnosticism, with Frederic Harrison, who had championed the pseudo-scientific creed of Positivism, with Cardinal Newman for his "Essay on Development" (1878) and his "Essay on Miracles" (1870). Even when merely speaking on some undisputed topic he would tend to take the attitude of a debater. He would sum up the past history of a question he was discussing by arguing it out (in a sort of shadow-debate) with the ghosts of Cuvier and Buckland or with unnamed but misguided naturalists of still earlier times. In his Presidential Address to the Geological Society (1869)—surely no occasion for controversy—he introduces his brief thus: "As your attorney-general for the time being, I thought I could not do better than to get up the case with a view to advising you." The whole essay is a fabric of argument, showing that Evolution includes rather than contravenes certain older theories, a rebuttal of Sir William Thomson's charge that geology was "in direct opposition to the principles of Natural Philosophy."

Huxley was thus ever the advocate, ever the warrior, sensing conflict and rushing to it with an eagerness more even than is justified by his love of truth and freedom of

[54] Walker, "Lit. Vict. Era," p. 238.

thinking. Yet he, too, like Darwin, knew plenty of ill-health. When scarcely out of his boyhood he had spent an afternoon in the dissecting-room, and had been poisoned in some mysterious manner. The strange languor that fell on him then left with equal strangeness during a visit to the country but would return to torment him from time to time. In 1888 his health made him withdraw from public activities, but he continued to write with as much spirit as ever until his death in June 1895.

It has been not altogether fair to quote Huxley piecemeal, for a part of his power lies in the sweep and massing of grand ideas in splendid and solemn periods. One such large-scale example must be given. Here is one that expresses the most typical of his doctrines according to his most characteristic literary means. After personifying science as Cinderella, and theology and philosophy as the two ugly sisters, he continues: "Cinderella is modestly conscious of her ignorance of these high matters. She lights the fire, sweeps the house, and provides the dinner; and is rewarded by being told that she is a base creature, devoted to low and material interests. But in her garret she has fairy visions, out of the ken of the pair of shrews who are quarreling downstairs. She sees the order which pervades the seeming disorder of the world; the great drama of evolution, with its full share of pity and terror, but also with abundant goodness and beauty, unrolls itself before her eyes; and she learns, in her heart of hearts, the lesson that the foundation of morality is to have done, once and for all, with lying; to give up pretending to believe that for which there is no evidence, and repeating unintelligible propositions about things beyond the possibilities of knowledge.

"She knows that the safety of morality lies neither in the adoption of this or that philosophical creed, but in a real and living belief in that fixed order of nature which sends social disorganization upon the track of immorality,

as surely as it sends physical disease after physical trespasses. And of that firm and lively faith it is her high mission to be the priestess."

Of that same firm and lively faith, it was Huxley's mission to be the spokesman. More even than a writer of books of science, he was the interpreter of the inwardness of science to the great public both without and within the laboratories. He was an ideal spokesman, for he believed wholly in the worthiness of his creed, and he advocated it daringly, aggressively, wisely, as well as with all the literary resources of one who had a great love and respect for his native tongue, who grew more fastidious as he grew older, to whom writing and speaking gradually transcended their original use as means of communication and became the medium of a pure and significant art.

CHAPTER XIX

FOLLOWERS

Too many men have had a finger in the evolutionary pie to allow a detailed study of each. Besides the greatest, however, there were a few others whose contribution, either in thought or in writing, was significant enough to make some discussion of them unavoidable. Of these, one of the most interesting was Henry Walter Bates,* whose originality in ideas, instinct for useful observation, and skill in setting forth what he had to say make his work well worthy of study. Above all, it was he whose work among the moths of the Amazon [1] "founded the subject of mimicry"—a sort of protective coloring—"from the evolutionary standpoint."

In 1848 he started out for South America in company with Wallace and, when after four years of work along the Amazon, his companion left, Bates stayed on alone, not returning to England until 1859. Like so many others—Darwin, Huxley, Wallace, Hooker—his travels formed the greatest influence in his career. But Bates stayed longer and worked more thoroughly in his chosen field than any other of them. He specialized in insect study, and eventually collected *eight thousand species* [2] hitherto unknown! What this alone would have meant to evolution may be suggested by a glance at the arrangement of so many species into families according to their affinities. But Bates did far more by finding an order in the chaos of their life-habits. His discoveries were com-

* (1829-1892.) [1] Darwin's "Life and Letters," II, p. 184.
[2] He collected many plant species also.

municated to the Linnean Society from time to time, some of them proving of the greatest value to Darwin as illustrations of natural selection at work.

Bates's "Contributions to an Insect Fauna of the Amazon Valley" [3] was read before the society on November 21, 1861, and made an instant impression. Darwin called it "one of the most remarkable and admirable papers I ever read in my life . . . too good to be largely appreciated by the mob of naturalists without souls." Naturalists without souls are presumably those who love to collect species for species' own sake, piling up unrelated facts and details and shying away from the really inductive act of marshalling details according to some central principle, who cannot see the more sweeping implications of their own work, whose writings may become useful for reference but are not to be read. Quite of an opposite type is Bates, though he, too, was an indefatigable collector and though the appendix to this very paper is a descriptive catalogue of species. The bulk of this seventy-page essay, however, is fascinating to read; it introduces the reader to well-organized ideas, vividly expressed. It begins with a minute but perfectly clear anatomy of certain moths, explaining their peculiarities of structure as due to local isolation, proceeds to give figures on the geographical distribution of various species of moths in South America, and goes on to a discussion of their habits. From this he advances to what must have especially delighted Darwin.[4] "The process of the creation of a new species," writes Bates, "I believe to be accelerated in the *Ithomiæ* and allied genera by the strong tendency of the insects, when pairing, to select none but their exact counterparts. We see here the manufacture, as it were, in process. We find, in this most instructive case, all stages of the process, from the commencement of a local variety . . . to the perfect segregation of one . . .

[3] In "Linnean Soc. Trans.," Vol. XXIII, 1862. [4] *Ibid.*, p. 501.

considered by all authors as a true species." With a sneer, he advises "closet naturalists" to study species "in nature and with strict reference to the *geographical relations* of their varieties." Thus he illustrates natural selection as it was actually found to apply among Brazilian insects.

The most original part of his work was in explaining mimicry among insects. This is a form of resemblance [5] "in external appearance, shape, and colours, between members of widely distinct families. An idea of what is meant may be formed by supposing a Pigeon to exist with the general figure and plumage of a Hawk." Obviously such a pigeon would be safer because of its dangerous look than would one with the normal mildness of the dove in its every feature. So, too, a harmless moth with the markings of a vicious wasp or of a foul-tasting beetle would have an advantage in the competition for existence over its unconcealed brothers and would thus be naturally selected,[6] "the selecting agents being insectivorous animals which gradually destroy those sports or varieties that are not sufficiently like *Ithomiæ* [undesirable as food] to deceive them."

The descriptions are full of color, clarity of outline, and motion. The language, though this was written for specialists, is no more technical than it must be, and the ideas are illustrated by means of a host of literary devices. The article, in short, is both good science and good literature.

A nearer approach to pure literature is Bates's other and more famous work, "The Naturalist on the River Amazons" (1863), in which he [7] "does not confine himself to his entomological discoveries, nor to any other branch of Natural History, but supplies a general outline of his adventures during his journeyings up and down

[5] *Ibid.*, p. 502. [6] *Ibid.*, p. 512.
[7] "Appreciation," by Charles Darwin.

the mighty river, and a variety of information concerning every object of interest, whether physical or political, that he met with by the way." It is thus a book primarily of travel with a little science thrown in here and there, full of interest for anyone who cares to see unrolled a vast panorama of a strange world, a unique civilization in action before a back-drop of even stranger scenes. The writing is characteristically vivid and picturesque, though it suffers from what seems to be the author's conscious desire to be literary rather than technical. He becomes stilted at times, fortunately not too often. Characteristically the best parts of the book are those that deal with the insect life which the author knew so well.

Two years after Wallace left his partner Bates to work the Brazilian field for himself, the former again left England. This time he travelled east instead of west, destined for an eight-year sojourn among the islands of the Malay Archipelago. He had exhausted the opportunities of the New World—in his own opinion—had written and published his "Travels on the Amazon and Rio Negro" (1853), of which Darwin said, "I was a *little* disappointed; hardly facts enough," and he wanted new material upon which to expend his abounding energies. The swarming life of that little known region supplied him with plenty. He began writing and sending home paper after paper. It was one of these early communications which expounded his own independent view of natural selection and has given him a special sort of associative immortality by linking his name inseparably with Darwin's. Moved, perhaps, by the honorable action of his colleague, he responded in kind; he never asserted his priority (as Patrick Matthew [1] often and rather absurdly did) but spent part of his life in advancing the fame of Darwin's discoveries.

[1] See Chapter VIII above.

Probably his greatest and most thorough original work dealt with "That almost keystone of the laws of creation, Geographical Distribution." For example, there was a short Linnean paper in 1860 on "Zoölogical Geography of the Malay Archipelago," marked by Wallace's usual tremendous theorizing. Facts are not numerous; a sort of final apology laments that only such [*] "have been adduced as a traveller's notebook can supply. The argument must therefore lose much of its weight from the absence of detail and accumulated examples" . . . and the reader must be satisfied with the "present imperfect outline in anticipation of the more detailed proofs and illustrations which I hope to bring forward on a future occasion."

Whatever lack there is of concrete facts is more than made up by the oversupply of imaginative induction and the real gorgeousness of the writing. The object of the paper is to point out the precise limits of two regions both within the same archipelago, in the belief that the "western islands belong to the Indian and the eastern to the Australian region" so far as the character of their animals is concerned, and "to call attention to some inferences of great general importance as regards the study of the laws of organic distribution." Later writings of his led to the plotting of "Wallace's line," supposed to divide these regions geologically, and commonly accepted as real, until 1899, when the Siboga expedition discovered submarine connections that destroyed his theory.

He writes with extreme vividness, drawing a powerful contrast between the two regions, thus: "In one the marsupial order constitutes the great mass of the mammalia; in the other not a solitary marsupial animal exists. The Australian region is one of the richest in the world in Parrots; the Asiatic is (of tropical regions) the

[*] "Zoölogical Geography," etc., p. 172.

poorest . . . so that in a few hours we may experience an amount of zoölogical difference which only weeks or even months of travel will give us in any other part of the world!" Constantly the reader's viewpoint seems regarded; the descriptions are full of color and character, the argument clearly defined and convincingly set forth. Many of the vast continental changes he assumes are narrated in the most orotund of styles, and the perfection with which each sector of the essay dovetails into the rest is most pleasing. The conclusions are characteristically vast; that New Zealand and Australia were once joined to the tip of South America; that plants change less rapidly than insects, which, in turn, change less rapidly than mammals, so that Wallace forms a new biological law,[10] "The duration of life of species would seem to be in inverse proportion to their complexity of organization and vital activity."

This paper, not very important in itself, yet provides an excellent short sample of what Wallace was doing all his life. It represents his typical mental habits of rapid and daring generalization based upon striking observation in romantic and exotic regions, combined with promises of later factual proof. It is brilliantly, fascinatingly told, with much narrative and descriptive skill and a convincing—or persuasive—power. And it deals with the one really original matter of which Wallace did know much—geographical distribution of animals. At the same time Philip Sutley Sclater was working on the same question, but he limited himself to birds, and soon fell into the ranks under Wallace's leadership. That enthusiastic man began sending home papers on birds, with especial attention paid to their distribution. Before he was ready to turn out his great work on the general problem of the distribution of all animal forms throughout the world, all sorts of special questions, some social or political, occupied

[10] Zoölogical Geography," etc., p. 184.

his ready pen. In 1864 he, like Huxley, faced the matter of man's evolution. In his essay "On the Phenomena of Variation" he suggested before anyone else had done so that "during late ages, the mind will have been modified more than the body." Yet not long after (1869) he was writing to Darwin that, in his belief, the soul of man could not have been produced by natural selection but only by some "additional and proximate cause"; in other words, by direct creation.

Wallace wrote rapidly and with prolific ease. A mere summing-up of the titles of his books and essays would prove excessive, but a few stand out. Thus there was his scientific journal of travels, "The Malay Archipelago" (1869)—"excellent,[11] and at the same time most pleasant to read." In 1870 a group of essays was collected into a volume entitled "Contributions to the Theory of Natural Selection." In his preface to this work Wallace points out just how much he had done for the development of that theory, and just where his claims must cease. He goes on: "I have long since measured my own strength, and know full well that it would be quite unequal to the task"—of writing the "Origin of Species"—for he admits that he has not "that untiring patience in accumulating, and that wonderful skill in using, large masses of facts of the most varied kinds—that wide and accurate physiological knowledge—that acuteness in devising and skill in carrying out experiments, and that admirable style of composition at once clear, persuasive, and judicial—qualities which, in their harmonious combination, mark out Mr. Darwin as the man, perhaps of all men now living, best fitted for the great work he has undertaken and accomplished."

Wallace's candor and fairness throughout this episode are fully illustrated and supply a pleasing obverse to Darwin's honorable treatment of the trust once imposed

[11] Darwin, "Life and Letters," Vol. II, p. 294.

in him. Besides that, it is clear that Wallace understood his own shortcomings and the temptations to which he so easily yielded, the temptations to too quick and ready conclusion, too wide generalization, too little accumulation of fact.

His next important book is the greatest of his career—"The Geographical Distribution of Animals with a Study of the Relations of Living and Extinct Faunas as Elucidating the Past Changes of the Earth's Surface." * These two volumes, totalling more than a thousand pages and forming what Darwin called a "grand and memorable work," were planned for many uses; reference, casual reading, study. The author calls it "a kind of dictionary of the geography and affinities of animals" containing "information now scattered through hundreds of volumes." Yet there are illustrated plates and special simplifications "in order to make the book more intelligible to those who have no special knowledge of systematic zoölogy."

The plan of the book is—in his own naïvely self-satisfied language—"quite novel." The various genera are traced about the earth to their various habitats, are linked to other groups in other lands, and to extinct forms in the same lands. "Species are systematically disregarded" as too unstable for the purpose. The conclusion is that the entire world may be divided into several main divisions, "zoögraphical continents," according to the animal life of each. The book is thus intentionally an expanded version of Chapters XI and XII of the "Origin," much as Darwin's "Variation under Domestication" is an enlarged Chapter I.

The spirit is essentially different, for it reflects the personality of a very different man. There are unfortunate revelations of self-satisfaction showing through the somewhat formal, yet alert, sentences. The words and phrases flow smoothly, and the book reads easily. It takes up

* (1876.)

great matters, yet leaves one with a somewhat empty feeling. Wallace has big ideas, an interesting and persuasive style, but he seems never to be doing a really thorough job. Whatever he wrote, even when it was a compendious dictionary, gives the impression of an advance sample for which the real work was to be done later. One element in causing this impression is his considerable dependence upon other writers. A second is the comparatively large proportion of theory in everything he wrote. Certainly one element is his use of the literary method of choosing a single striking illustration of a general statement rather than presenting a host of examples. This method of illustration is a wonderful time-saving device; it makes the generalization concrete and fills it with body. But it fails to make it convincing; one swallow does not make a summer, nor one instance a proof. The reader imagines that the author knows more than he gives, but that, either because he is in a hurry or because he is writing for non-specialists, he will not stop to give more at present. Wallace is not always exactly a popularizer, but he always writes with one eye on the general public. Before beginning as a naturalist he was a teacher of English; perhaps his excellent, masterly control of style can be thus explained. Perhaps his faults grew likewise from the habit of preoccupation with words *as words,* from the teacher's need of interpreting great ideas for immature minds.

After his great colleague had died, Wallace wrote an exceptionally well-balanced restatement of evolution, calling it "Darwinism, an Exposition of the Theory of Natural Selection with Some of its Applications." * This book is a sort of "Origin of Species" and "Descent of Man" combined and popularized, with such modifications as Wallace himself saw fit to introduce. The principal points in which he differs from Darwin are these: he does not admit that sexual selection has had any force at all

* (1889.)

in altering the colors of animals. Protective coloring and mimicry he accepts fully, since natural selection can account well for them. Indeed he adheres to natural selection more completely even than Darwin, utterly rejecting the idea that use and disuse of organs may have played any part at all in forming them. He adds one discovery of his own; that there are certain "recognition marks" borne by birds, mammals, and insects, by means of which members of the same species are enabled to recognize one another readily and thus to avoid danger. He supposes that patterns and special colors not explained on any of the above bases must be the result of nervous and chemical conditions and thus have been formed directly. He argues[12] that the "extremely rigid action of natural selection must render any attempt to select mere ornament utterly nugatory, unless the most ornamented always coincide with 'the fittest' in every other respect; while, if they do so coincide, then any selection of ornament is altogether superfluous." He does not adopt Darwin's explanation of plant-migration during the ice-age—a flight before the invasion of cold—preferring to explain the dissemination of plants by citing the seed-carrying power of the wind. His most vital exception is taken in regard to the human mind; for Wallace insists on[13] "the existence in man of something which he has not derived from his animal progenitors—something which we may best refer to as being of a spiritual essence or nature." As might be expected, his most genuine contribution is in his treatment of geographical distribution. Despite these points of divergence, the book is in general a defence of Darwinism, one well calculated to win adherents to that hypothesis.

It is a well-designed volume, approaching the subject from the probable viewpoint of the reader who is not really a naturalist. Thus—unlike Darwin, who began

[12] "Darwinism," p. 295. [13] *Ibid.*, p. 474.

with his experiments on domestic animals and plants—Wallace begins by asking, "What are 'species'?" In taking up the struggle for existence, he discusses the ethical aspects of the question, which have nothing whatever to do with the correctness of the theory, but which any ordinary person would be anxious to understand. The consideration of man's descent is taken up, psychologically, last of all. The book is well-proportioned, too, never giving up too much to any one phase, however intricate. The language is beautifully smooth, and the exposition luminous. "There never lived a better expounder than you," Darwin had once written,[14] and Wallace merited the praise. His picture of the rich, full lives and clean, swift deaths of the wild creatures is certainly thrilling, and may well persuade a reader that even the redness of tooth and claw is somehow beautiful and even just. A person who knows little of science and wishes to understand evolution would do better to begin with this book than with the "Origin of Species."

Wallace's varied activities led to many and strange writings. He became—as might have been anticipated from his pronouncements on the soul—a believer in spiritualism. For many years he worked to aid the Society for Psychical Research. The séances of Eusapia Palladino convinced him despite her being discredited by an investigating committee at Cambridge. His book on "Miracles and Modern Spiritualism" (1875, second edition, 1896) presents his views on this subject, and shows all the comforts and consolations provided by "spiritualism, if true. . . ." His outstanding books on social questions are: "Land Nationalization" (1882), "Vaccination" (1855), "Social Environment and Modern Progress" (1913). He also wrote an autobiography. "My Life," which appeared in 1905.

Other scientific works continued to appear from time

[14] "Life and Letters," Vol. II, p. 296.

to time. His "Island Life" (1880) is a somewhat popularized and certainly more thorough treatment of the question raised in his early paper on the two regions of the Malay Archipelago. "The Wonderful Century" (1899), an oratorical appreciation of the increasing control of nature by man, with a philippic against man's misuse of that control in militarism, greed, conquest, oppression, and social inequality, cites twenty-four prime discoveries of the nineteenth century as against only fifteen "of all preceding ages." In 1903 he published an astronomical book, "Man's Place in the Universe," which studies the question of whether other heavenly bodies may be inhabited and concludes that probably our world alone bears living beings. The book is stirringly composed, and both sides are very fairly presented; but it is marred by two weaknesses. In the first place, the author uses the central position of the earth [15] in a solar system which is itself central in the universe as a mystical reason why this planet alone of all the million or more masses in existence should have been chosen for the honor of bearing life upon it. In the second place a disproportionate amount of the material is taken (with full acknowledgment, of course) from Richard Proctor's "Other Worlds than Ours. . . ." It was followed in 1907 by "Is Mars Habitable?"

In 1910 he published one more volume on natural selection, and this time the viewpoint of natural theology almost overbalances that of pure science. This child of his old age is quaintly named, "The World of Life, a manifestation of Creative Power, Directive Mind, and Ultimate Purpose." Of all the authors who have striven to justify the ways of God to man, Wallace was perhaps the best fitted by objective knowledge to do the work efficiently. He finds in the very existence of disease-bear-

[15] That is, between the inner and the outer groups of planets. See Chapter XXIII.

ing bacteria a beneficent aim: [18] "To seize upon the less healthy individuals—those which are slowly dying and no longer of value in the preservation of the species."

He disagrees sharply with Haeckel's view of the insignificance of man, and to the question, "Is nature cruel?", he answers with an emphatic "No." Apart from the teleological purpose of the book, it is replete with the curious details about strange beasts, the odd and powerfully stimulating theories that Wallace knew so well how to put into words. . . . He was long known as "the last of the giants," a lonely figure in an age ever more at variance with the days of his youth and with the distinctive doctrines for which he did battle until his death in 1913.

Naturally enough, the opposition which had been so bitter at first did not disappear at once but only gradually and in part. Some of the controversies have been traced in connection with Huxley or with Darwin himself; others remain to be mentioned. Perhaps the most numerous of the opponents of evolution were clergymen—and their allies, such as Gladstone—and as such most of their writings fall outside the field of scientific literature.

A rather elaborate study of this long conflict is Andrew Dickson White's "History of the Warfare of Science with Theology in Christendom" (1894). In this book, the first president of Cornell University, evidently a liberal religionist, traces the various advances which were made by science against the opposition of theological conservatism. He gives the names of many clergymen, in England and the United States, who opposed evolution as ungodly and of several who found ways of reconciling it with their faith. Perhaps the most distinguished of the former group was Dr. Edward Bouverie Pusey (1800-1882), one-time leader of Newman's Oxford Movement, and the butt of Carlyle's ridicule of "Puseyism." In 1878 Dr. Pusey wrote a book to prove only "Un-science, not Science, ad-

[18] "World of Life," p. 413.

verse to Faith," and he included evolution as one form of un-science.

Perhaps the most gifted writer among the reconcilers was Charles Kingsley [17] (1819-1875) who, be it remembered, had been a considerable amateur geologist long before 1859 and had been among the first to hail Darwin's *magnum opus* as a new revelation. His many popular lectures sometimes touched on scientific subjects and not as a spiritual man who fears the destructive influence of a materialistic approach to wisdom, but with all sympathy for science as well as with full reverence for the faith he preached. In his charming fairy-tale, "The Water-Babies" (1863) there is more than one whimsical exposition of the scientific method and of evolutionary matters. Kingsley, never distinguished for intellectual subtlety, had, by a happy intuition, guessed the future trend of thought, and he took advantage of it most pleasantly.

Leaving aside, then, the great bulk of purely theological controversies over evolution, let us glance at a few of the scientific ones. Sir Richard Owen continued as long as he lived (until 1892) to oppose—partly by ignoring Darwin's work, which he seems never to have fully understood,—all ideas of a real, physical evolution of life. His early doctrine of the *derivation* of all vertebrate animals by some mystic process from a single *archetype,* or purely mental design of an ancestor, continued to be the leading item in his credo. Darwin was often puzzled whether to regard Owen as for him or against him. In the long run his influence was consistently against any definite explanation of the origin of species. In his "On the Anatomy of Vertebrates" (1866), he declares that origin to be still a mystery; it must have been "an orderly succession" and "progressive," but it "remains in the hypothetical state exemplified by the guess-endeav-

[17] See Chapter XXI.

ours of Lamarck, Darwin, Wallace, and others," which he also calls "conceptions of what may have, not observations of what have, originated a species," "mere figurative language" which "explains absolutely nothing," and so on.

The book is a vast store-house of anatomical knowledge, loftily and sometimes strikingly written. The methods of classification of animals show no change from those of Owen's earlier works outlined above. His dispute with Darwin is referred to often and bitterly and his own idea of derivation again expounded as a better explanation, for [18] it "sees among the effects of the innate tendency to change, irrespective of altered surrounding circumstances, a manifestation of creative power in the variety and beauty of the results; and, in the ultimate forthcoming of a being susceptible of appreciating such beauty, evidence of the preordaining of such relation of power to the appreciation." Again and even more astonishingly he declares, "I believe the Horse to have been predestined and prepared for Man. It may be a weakness; but, if so, it is a glorious one, to discern, however dimly, across our finite prison-wall, evidence of the 'Divinity that shapes our ends,' abuse the means as we may."

Thus, despite Owen's enormous prestige in his own day and despite his many discoveries and his great work for natural history, there is no more to be said about him. His long life meant a succession of repetitions of the early doctrines, applied here and there to newly found fossils, in language sometimes technical and sometimes high-sounding, and with a growing impatience and irritation.

The same work was being carried on in the United States by Jean Louis Rodolphe Agassiz (1807-1873) a native of Switzerland, who was called to Harvard Uni-

[18] "Anatomy of Vertebrates," p. 715.

versity to establish a department of natural history there. His early work, which dealt mostly with fishes, was written in French. His American career met with remarkable popular success and gave him an influence that he used in order to oppose the spread of evolutionary thought. Unlike Owen, however, he managed somehow to preserve a calm and happy attitude toward life, which lends a pleasant tone to his popular writings. Even his "earnest protest against the transmutationist theory . . . a phantom" that "has a fascination for the human mind" is tolerantly phrased. A good idea of his writing can be obtained from the popular volume, "Methods of Study in Natural History" (1868), in which his more technical "Essay on Classification" is re-presented, simplified and with commentaries. He writes like a skilled teacher, simply, with ample illustration and tactful drawing of morals. Here are a few quotations which fairly represent his doctrines:[19] "Classification, rightly understood, means simply the creative plan of God as expressed in organic forms." [20] . . . "Man is the crowning work of God . . . but his physical nature is rooted in all the material characteristics that belong to his type and link him even with the Fish." [21] . . . "Breeds among animals are the work of man: Species were created by God." There has been, he holds, "creation after creation . . . every one stamped with a character peculiarly its own." [22]

One of the naturalists who harried and greatly annoyed Darwin was St. George Jackson Mivart,* strange philosopher, theologian, zoölogist, who, striving to reconcile these variant modes of thought, won the hatred of scientists only to be excommunicated for heretical opinions by his own (Catholic) church six weeks before his death. Dar-

[19] "Methods of Study in Natural History," p. 42.
[20] *Ibid.*, p. 71.
[21] *Ibid.*, p. 94.
[22] *Ibid.*, p. 270. This really great naturalist being no English writer, more need not be said about him here. * (1827-1900.)

win called him [23] "the man in England who knows most about the structure of the Simiæ . . . and who is bitterly opposed to my doctrines." Mivart wrote a charming monograph on "The Cat" (1881) and several other works, of which "The Genesis of Species" (1870) stands out most notably. The object of the work is reconciliation of the unacceptable evolutionary theory with "the more or less crude conceptions" prevailing, to attain a "*tertium quid*—the resultant of forces coming from different quarters." He shows that natural selection is not all of evolution, which "is, without any doubt, perfectly consistent with strictest and most orthodox Christian theology." The "insuperable . . . scientific difficulties" to pure Darwinism are set forth at length, very plainly and with no adornment nor any art save clear exposition. Darwin is belittled mainly by the device of overpraising Wallace, Mivart's solution, for which he claims originality though it is strangely like Owen's old doctrine, is that [24] "some internal force" is the real cause of evolution. Sudden, "saltatory" changes arise, and natural selection comes in only now and then to dispose of the few freaks that happen to be unfit to live.

One of the most curious of the objectors was Colonel George Greenwood, whose "Rain and Rivers (or Hutton and Playfair against Lyell and all Comers)," first issued in 1857, was revised in 1866 to include Darwin among the "all comers" whom he quixotically defied. The old colonel was in a bellicose mood when he wrote this book; he accused Lyell, the eminently respectable dean of geologists, of intentional insanity, charged evolutionists with the crudest blunders. One of his chapters is entitled "The Earth and Man Eternal, unless Destroyed by the Will of God," with which comfortable doctrine we may pass on to another.

William Henry Hudson, later famous as a delightful

[23] "Life and Letters." [24] "Genesis of Species," p. 341.

essayist on natural history, made his first appearance in English literature with a series of "Letters on the Ornithology of Buenos Aires." The third of these, read before the Zoölogical Society on March 24, 1870, is a denial of Darwin's statement that the Pampas woodpecker "never climbs a tree." After flatly denying this statement—with a little local pride as a native of the Pampas—Hudson goes on to say: "Mr. Darwin's *Researches* abound in similar misstatements when treating of the country. . . ." To this callow accusation the older naturalist replied—for once suspending his rule to avoid controversy—giving detailed observations of thirty-seven years before and citing the authority of Azara. "But," he asks, "is it not possible that this bird may have somewhat different habits in different districts, and that I may not be quite so inaccurate as Mr. Hudson supposes?"

With the passing of time more and ever more biologists came around to a complete acceptance of evolution, but the Darwinian factor, natural selection, was much disputed. Weismann's work in embryology led to the theory of the "immortality of the germ-plasm," which, by absolutely denying the possibility of acquired characteristics being inherited, made natural selection the sole power in the creation of new species. Wallace was of this opinion too, as was also the intensely energetic crusading Haeckel in Germany, whose "Natural History of Creation," "The Last Link," "The Evolution of Man," and other works insisted on a purely materialistic explanation of life. These men and their followers constituted a Neo-Darwinian school of thought, becoming "more Darwinian than Darwin," who, from the writing of the "Origin" and more as he grew older, had admitted that the Lamarckian factors might have been of some potency in inducing some of the changes that evolution tries to explain.

A valiant upholder of the moderate position was George John Romanes (1848-1894). He was, in a sense,

the inheritor of the master's mantle, for he was permitted to publish Darwin's essay on *"instinct"* as an appendix to his "Mental Evolution in Animals" (1885). This very hypothetical work in the field of comparative psychology is really a sequel to Romanes' earlier and more factual study of "Animal Intelligence" (1881). It considers mind objectively, recognizes that it is found in all animals, and traces a supposed growth in the various faculties through the ascending levels of the animal kingdom. The evolution of man's intelligence is here untouched, being left for a later work on "Mental Evolution in Man" (1888). All these books are philosophical as well as scientific and show the special, highly abstract terminology that so often marks works of metaphysics. Romanes was also the historian of the evolutionary movement, his "Darwin and After Darwin" (1892) being a vigorous and learned summary of evolution for cultured laymen, as well as a warning to avoid being misled by the Neo-Darwinians. This book, being intended for what scientists call the populace, has more of a literary tone than the others, typical cases being given to illustrate crucial issues; and there are excellent plates with unusually full explanations. The tone of the book is too controversial for pleasant reading.

Since then Darwin's doctrine of infinitesimal variations accumulating over long periods has come in for a share of criticism. Just after the beginning of the new century, Hugo de Vries, of Holland, demonstrated that sudden changes occur. His book, "Species and Varieties, their Origin by Mutation" (1904), sets forth this thesis. Vernon Kellog's "Darwinism Today" (1917) gives a modern summing up of what various biologists have written more recently. With the increasing development of bio-chemistry and bio-physics, the complication of the writing on all these questions increases many-fold, while such fundamental problems as whether acquired characteristics are

inherited remain unsolved. Popular—even reasonably non-technical—treatments seem to be no longer customary products of the pens of pioneering discoverers but are merely rewritten at second-hand, often by journalists with little scientific training. Attempts by State government to restrain teaching of evolution by law have so far succeeded in but three States of the Union and not elsewhere.

What future discoveries may bring forth no one can predict with certainty, but it seems beyond question that the hypothesis of evolution, which explains so much, has come to stay as a permanent addition to the cultural wealth of the civilized world. The great problems which that theory has opened may perhaps be solved, as W. Russell Brain suggests,[25] by a change in our modes of thought. More attention to function, less to structure, *may,* according to that author, remove the difficulties from our believing in the inheritance of acquired characteristics. The founder of this hypothesis did not doubt that such inheritance does take place. "His followers," says Dr. Brain, "have rejected this view. Is it rash to believe that the insight of the master led him nearer the truth than their agnosticism has brought his disciples, and that the future of Darwinism is—Darwinism?"

[25] In "Galatea or the future of Darwinism" in the "Today and Tomorrow Series," 1927.

PART IV

CERTAIN SPECIAL TYPES

To speak as the common people do, to think as wise men do.

Roger Ascham.

Man is interested in nature just in the proportion that he sees himself mirrored there.

P. M. Hicks.

There is no surer sign of his not appreciating the aim and scope of the science he cultivates, than a craving to load it with names.

Joseph Dalton Hooker.

Those who write as they speak, though they speak very well, write badly.

Buffon.

People generally admire what they do not comprehend.

Fontenelle.

What are the conditions of a science? and when may any subject be said to enter the scientific stage? I suppose when the facts of it begin to resolve themselves into groups; when phenomena are no longer isolated experiences, but appear in connection and order; when, after certain antecedents, certain consequences are uniformly seen to follow; when facts enough have been collected to furnish a basis for conjectural explanation; and when conjectures have so far ceased to be utterly vague that it is possible in some degree to foresee the future by the help of them.

Till a subject has advanced as far as this, to speak of a science of it is an abuse of language.

James Anthony Froude.

Literature is all one—and indivisible. All literature is the expression of feeling, of passion, of emotion, caused by a sensation of the interestingness of life. . . . The makers of literature are those who have seen and felt the marvellous interestingness of the universe.

Arnold Bennett.

The sifting of language is the weighing of thought.

Rt. Hon. Sir T. Clifford Albutt.

CHAPTER XX

THE GREAT SYNTHESISTS

No one can obtain a complete or well-rounded view of the literature of science without recognizing that it divides naturally into certain distinct and special types. The most obvious distinction is drawn on the basis of content; there are works on astronomy, on chemistry, on mechanics, on zoölogy, and so forth. This might be called the *vertical classification,* for, as would be more evident from a diagram, it is a distinction based upon differences in *subject-matter* and not at all upon *differences in level* or complexity. The latter—or *horizontal*—distinction may be drawn likewise; that is, scientific books may be classified into elementary, intermediate, advanced, just as courses of study are divided. There is a third mode of dividing scientific literature, which does not wholly accept either of the above yet does in part make use of both; this method of classifying is based upon the *author's aim* and viewpoint, his attitude toward his subject and toward his readers, his method of approach to the whole problem of expressing and conveying his ideas. This essentially literary means of dividing the field, which we may call the *oblique* classification, is the one that will be followed in the present chapter.

For our purposes it has several real advantages. In the first place, it is a distinction based upon qualities that will weigh definitely in any critical evaluation. The literary analysis of any work need not be at all influenced

by the question of whether it deals with nebulæ or molecules and only indirectly by the question of whether the particular book was written for beginners or for those who already know something about the subject. But criticism cannot overlook the writer's aim.

Second and more important, the oblique classification provides a convenient means of allowing discussion of several typical corners of the field of scientific literature. This field, so vast as to be quite beyond the scope of a single volume, can really be studied best in this way. Instead of making a very superficial survey of the whole field or a really thorough and detailed microscopic inspection of some one quarter-furrow so small as to be unilluminating, is it not preferable—at least for a first sketcher of the terrain—to make a group of representative studies, each fairly detailed, so that a fair notion of all the field may be obtained? Some of the more prominent aspects have been gone over somewhat more minutely in the preceding three parts; some of the quainter, though no less interesting, aspects will be touched upon in this.

Thus, among writers upon scientific subjects, some of the most original and most ambitious have sought for a key that might unlock the ultimate mysteries of nature. Like Faust in his midnight study, they have refused to be content with the ordinary scientific process of accumulating particular details and eventually organizing them into small particular systems. Such minds seek to connect various sciences into one vast and complete system. Some of them have hoped thus to uncover what is called "the plan of creation." Some have aimed at devising a philosophical system in more genuine accord with the objective facts discovered by the various sciences than most philosophies have been able to achieve. Some have been interested in scientific method rather than in any of its products. Certain of them have been men of primarily

religious natures, who hoped that a study of the connection of the sciences would tend to show the order and intelligent governance of the universe, thus dispelling the materialistic influence of much physical study in a single direction.

Perhaps the first of the great synthesists was Aristotle. He was first in so many branches of science and of thought that for centuries he was known simply as *the Philosopher.* He literally created whole realms of thought; zoölogy—including classification—human physiology, mathematics, astronomy, ethics, literary criticism, government are a few of the fields within which his genius exerted itself. A like expansive intellect was that of Francis Bacon * who, as all remember, took the whole of knowledge to be his province. Bacon was so busy a man, had so many cares in connection with his holding the office of Lord Chancellor, that his scientific interests did not receive the time or attention they deserved. It is possible, too, that even if he had had more time to spare he would not have worked less hurriedly; he was a man of essentially impatient mind, a brilliant and swift thinker, a tremendous conceiver, without the steady, driving persistence that is needed for success in special scientific researches. He is often pointed to as the "father of modern science," the inventor of the inductive method, the first man to realize the necessity of objective, experimental learning. Of late there has been a reaction away from the great adulation which Bacon once received; Professor Morris Raphael Cohen, for example, points out that Copernicus, Kepler, Galileo, Harriot, Gilbert, Harvey, and Vesalius had used the inductive method before Bacon expounded it, that Bacon was opposed to some of the most important advances of the day (such as the Copernican astronomy), that "he himself, despite all his grandiloquent claims, failed to make a single important

* (1561-1626.)

contribution to science." [1] "No wonder," he adds, "that a real scientist like Harvey was moved to say that Bacon wrote science like a Lord Chancellor."

Bacon's claim to scientific greatness is based upon a series of huge manifestoes, or proclamations of policy, in the realm of thought. These were couched in terms comparable to those in a statesman's declaration. He did indeed write certain works whose contents are simply records of fact and explanations of those facts; these are his minor works, such as his "Sylva Sylvarum" (1627), a collection of fragmentary observations, loosely arranged under the general topics of mechanics, sound, heat, chemical combinations, gardening, medicine, species, physiology, and what is now called psychology. Though there is much knowledge shown in these minor works, it is not systematic; they appear to be the notebooks of an investigator rather than his real work. Furthermore, it is not upon such works as these that his fame rests, any more than upon his pithy short essays.

Bacon's greater works are not collections of learning already made but outlines of future discovery. Not content with the state of science in his own day, he attributes its lack of real advancement to the inefficiency of the instruments used. There was too much dependence upon authority, too much confidence in abstract reasoning, too little collection of tangible evidence, too little use of instruments of measurement. He pointed out that philosophy had advanced scarcely at all since ancient Greek days, whereas mechanic arts had shown considerable progress due to the realistic, empirical spirit in which the latter had been treated. The same spirit, applied to matters of learning, would bring about a like progress, he thought, and he set himself to sketch out the methods to

[1] "The Myth about Bacon and the Inductive Method," *City College Alumnus,* XXII, 7 (Sept. 1926).

be pursued in that new campaign of the human mind against its old enemy, ignorance.

The various books that he actually completed were planned to form parts of a vast work to be known as "The Great Instauration" (*Instauratio Magna*); that is, the great establishment or structure. They consisted of "The Advancement of Learning" ("The Two Books of Francis Bacon of the Proficience and Advancement of Learning Human and Divine," 1604) and "Novum Organum; or, True Suggestions for the Interpretation of Nature," 1620). These books he regarded as of such world-wide importance that he translated them into Latin, then the international language of culture and learning. Ever conscious of his great mission as reformer of the modes of thought, he wrote in stirring vein of the abuses that roused his displeasure: "So, in natural history, we see that there hath not been that choice and judgment used as ought to have been; as may be seen in the writings of Plinius, Cardanus, Albertus, and divers of the Arabians; being fraught with much fabulous matter, a great part not only untried but notoriously untrue." He protests against the "Overmuch credit that hath been given unto authors in sciences in making them dictators," of which error "the damage is infinite that sciences have received thereby, as the principal cause that hath kept them low, at a stay without growth or advancement." He objected to the usual habit of scholars who classify, the "over-early and peremptory reduction of knowledge into arts and methods," also against "a kind of adoration of the mind . . . by means whereof men have withdrawn themselves too much from the contemplation of nature and the observations of experience," against "impatience of doubt, and haste to assertion without due and mature suspension of judgment." But, above all, Bacon the great synthesist was displeased to note "that after the

distribution of particular arts and sciences, men have abandoned universality."

His aim was to correct these vicious habits. Naming them was almost sufficient in itself; beyond that all he could do was to name their opposites—as in a tone of approval. He suggested that scholars ought to use "spheres, globes, astrolabes, maps and the like" in addition to books; that "History Mechanical" or, as we should say, applied science, ought to be taught; that observation, not tradition, be made the final authority. To teach men how to use observation, he wrote the "Novum Organum," or "new instrument," in which the method of induction is expounded; "the end of our new logic is to find . . . not what agrees with principles but principles themselves." To accomplish this aim, "our method is continually to dwell among things soberly," to cultivate a "just and legitimate familiarity betwixt the mind and things."

There is much that might be said about Bacon's ideas, about his vast similes of the mental obstacles to fair judgment—the idols of the den, the tribe, the market place, and the theatre—about his almost uncanny precision in constructing aphorisms. Let it suffice to point out that he was constantly on the search for future developments in science and for the possibility of linking the various branches of learning into a single majestic whole. His "Great Instauration" closes with an outline of "The Coast of the New Intellectual World; or a recapitulation of the *deficiencies* of knowledge, pointed out in the preceding work, to be supplied by posterity."

His literary style is masterly, according to the manner of his own spacious days; it is vigorous, bold, reasonable, with flashes of noble barbarity, yet embellished and quaint. He can build Gothic sentences with Renaissance adornments, trimmed with allusions to classic Rome and Greece and with an occasional biblical or puritanical tang. And again he dearly loves a trim epigram. Nothing is

more typical of Bacon than his untiring search for "general axioms . . . not peculiar to one science." Yet in his "Sylva Sylvarum," he intentionally chooses a casual and rambling, fragmentary style: says he, "Methodical delivery is more fit to win consent or belief; but less fit to point to action; for they carry a show of demonstration in orb or circle, one part illuminating another; and therefore do more satisfy the understanding; but being that actions in common course of life are dispersed, and not orderly digested, they do best agree with dispersed directions."

It has seemed desirable to step thus far out of the period chosen for this study, because Bacon is so exactly and completely typical of the synthesists, so splendidly an example of the scientist who is also a writer, that no such book as this could afford to leave him unmentioned. A complete discussion of his work is not practicable here; Sir Humphry Davy summarized Bacon's achievement thus: [2] "He taught . . . that facts were to be collected and not speculations formed; and that the materials for the foundations of true systems of knowledge were to be discovered, not in the books of the ancients, not in metaphysical theories, not in the fancies of men, but in the visible and tangible external world."

The great influence which Humboldt * exerted over the mind of young Charles Darwin has already been mentioned, and something said about the baron's work, to indicate briefly his attempt at a general synthesis of various sciences. In later life, when the early enthusiasm had somewhat worn off, Darwin wrote to his friend Hooker about Humboldt, "I should say he was wonderful, more for his near approach to omniscience than for originality." That his omniscience did not include precision in matters of detail is shown by the added statement that "his geology is funny stuff." It is due rather

[2] "Chemical Philosophy," p. 21.

* Baron Friedrich Heinrich Alexander von Humboldt (1769-1859).

to his attitude toward his work, to the scope of his interests, to the widespread, all-embracing nature of his scientific ambitions. He was a field naturalist and travelling observer, a geographer, geologist, botanist, anthropologist. He practically founded the study of climatology by his discovery that weather seems to travel along certain *isothermal* lines which are not identical with the degrees of latitude. Characteristic works are his "Researches Concerning the Ancient Inhabitants of America," his "Personal Narrative of Travels" (1804), "Aspects of Nature" (1808), and his huge "Cosmos: Sketch of a physical description of the Universe" (1844).[3]

It is in this monumental study of "Physical Cosmography" that his "mind predisposed to generalization" is most freely and fully expressed. "I ever desired," declared the baron in his preface, "to discern physical phenomena in their widest mutual connection, and to comprehend Nature as a whole, animated and moved by inward forces." The work is divided into two huge parts; first, a collection of facts, astronomical, geological, biological; second, a history of science. His theme is that as science develops it reveals a "Cosmos, or harmoniously ordered whole, which, dimly shadowed forth to the human mind in the primitive ages of the world, is now fully revealed to the maturer intellect of mankind as the result of long and laborious observation." In this he contrasts sharply with Bacon, who, dissatisfied with the science of his day, planned a new beginning with new instruments of his own devising; Humboldt, full of pride in the science of his time, aimed merely to show its essential unity and harmony. His introduction takes in everything: comets, volcanoes, climate, physical geography, evolution, the beauty of nature, the philosophy of scientific doubt, the literary style appropriate for works of science. He was one of the many scientific writers who have touched upon

[3] Translation by Lieutenant Colonel Edward Sabine.

this literary question. "Conciseness," he felt, "may produce aridity, whilst too great a multiplicity . . . leads to a want of clearness" . . . "it is needful that thought should clothe itself freely and without restraint in such forms and with such elevation of language, as may be least unworthy of the grandeur and majesty of creation." That is typical of him, ever conscious of his high purpose, ever orating or, as it were, touching the stops that bring swelling basses into the tremendous fugue of his great organ-like technique. He was not satisfied to be a mere naturalist, for he was a man of the great world, too, and must be appreciated by statesmen and sovereigns as well as by lonely savants. He was sure that he could accomplish both objects; since "a certain degree of scientific accuracy in the treatment of facts is not incompatible with animated and picturesque representation."

The general plan of his "delineation of nature" is thus outlined: "Beginning with the depths of space and the regions of remotest nebulæ, we will gradually descend through the starry zone to which our solar system belongs, to our own terrestrial spheroid, circled by air and ocean, there to direct our attention to its form, temperature, and magnetic tension, and to consider the fullness of life unfolding itself upon its surface under the vivifying influence of light."

More than any other scientist he showed the influence of the Romantic School then dominant in the poetic world. His reverence for the wild and picturesque in nature, the awesome and majestic, testifies to his being a Romantic; his keen interest in savage life reflects the influence of a cult that followed Rousseau in admiring and envying the noble child of nature. His writing is Byronic, touched with a lofty emotionalism that often becomes turgid and pompously top-heavy. It does, however, differ from that of Byron in one fundamental respect; Byron was ever a rebel, and his wild extravagance

is steeped in the feelings of revolt against authority, while Humboldt, wealthy, aristocratic, and honored almost from the cradle, lectures an attentive world as if with some sense of stooping toward the common man. He seems to know that what he has to say is important because he says it, he, Humboldt the great. His nearest counterpart among our contemporaries is Count Keyserling, who has been likewise criticized—unfavorably—for his air of omniscience.

More ambitious even than the aims of the foregoing philosophers was the ruling ideal of Isidore Auguste Marie François Xavier Comte (1798-1857), an humble tutor of mathematics who evolved "a Doctrine," as Lewes has it, "capable of all that can regulate humanity; not a treatise on physical science, not a treatise on social science, but a system which absorbs all intellectual activity." The same critic declares [4] "Auguste Comte the greatest thinker of modern times, and one whose doctrine is to the nineteenth century something more than that which Bacon's was to the seventeenth and eighteenth." This is high praise, even from a professed disciple, but it is suggestive of the great stir which Comte's ideas made among the more liberal intellectuals of the early Victorian period. Despite a most unfortunate personality, compact of narrowness and conceit and once overturned by complete though temporary insanity, Comte managed to win the respect of such distinguished persons as John Stuart Mill, John Grote, and George Eliot, and the equal tribute of Herbert Spencer's vigorous opposition. It has been said that the ruling quality of the French mind is its passion for order; if this is so, Comte is the paragon of Gallicism. A mathematician by training, a man of almost inhuman precision in the most trifling matters of daily life—such as putting his hat invariably at the far

[4] Lewes, G. H., "Comte's Positive Philosophy" in the *Leader*, April 3, 1852.

left-hand corner of the table—he was grieved at the haphazard state of thought in his time and began early to force the meaning of the universe into a more systematic form. This became his life-work; quarrels with his wife, quarrels with his official superiors, quarrels with the patrons who supported him could not prevent him from going forward to the end of his predetermined task. Until the philosophy of evolution came to put a new complexion upon thought, it seemed as if his system of positivism might really become the mode of thinking and living in all the Western World.

As early as 1822 he had set down some of the essential ideas of his system in a "Plan for the Scientific Works Necessary to Reorganize Society." His later course of lectures on the same subject was interrupted by the inroads of mental illness; but as soon as possible he began to turn it into a book. The first volume appeared in 1830; the sixth in 1842 completed his "Course of Positive Philosophy," which embodies all the more important part of Comte's contribution to the thought of the world. Essentially his work was to appeal for a unified system of thinking about the various phases of the universe, and to show what that unified system was to be. A study of the history of culture, he maintained, shows that every science passes through three states or stages: a theological state in which phenomena are explained as having been caused by voluntary action on the part of a God or spirits; a metaphysical state in which phenomena are explained as resulting from some abstract principle, such as vital force; and a positive state in which phenomena are observed and recorded together with their observable antecedents. It is only such *positive,* or objective, knowledge that has any real scientific value; hence Comte's choice of "*Positivism*" as the name of his new creed. Most of the physical and even most of the natural sciences had passed through the two earlier stages and attained

to the positive, but the study of mankind—most necessary of all so far as human welfare is concerned—was still hovering between the theological and the metaphysical. No wonder that human conduct was so haphazard, undependable, that social institutions were so inefficient and unjust!

An important feature of the Comtist doctrine is a new classification of the sciences. This is twofold. In the first place, every branch of science has an abstract phase and a concrete phase; thus chemistry is abstract, for it analyzes ultimate truths about matter, while mineralogy, its concrete double, states specific facts about particular forms of matter. Furthermore all sciences (in their abstract phase) can be arranged in a certain serial order, the more particular and complex sciences depending absolutely upon the simpler and more general. Thus his arrangement would place mathematics at the foundation; proceeding toward the more and more dependent, we find them in this order: astronomy, physics, chemistry, biology, sociology. Each of these is one degree more specialized than the one before it; hence we might expect the first of the series to attain the positive stage first, the last to arrive there last. A study of history shows this to have occurred, and in Comte's day, it still remained to make a positive science of sociology. After expounding the philosophy and history of the other sciences in the first three volumes of his "Course," he devoted the remaining three to the laying down of the principles upon which he would establish a science of society.

Deducing his ideas from history, he declares social communities under certain circumstances always to act in particular ways. Now, if this hypothesis should become generally understood, enormous waste effort and bloodshed might be spared. The inevitable outcome of political struggles might be forecast with certainty, and the

opposition would cease to block such advances; even "the practical man, the man in the street, would no longer delay improvements by a dogged and short-sighted defense of his immediate interests and possessions; the day of bloody revolutions would be past, and history would thenceforward present a picture of rapid and orderly progress." [5]

Comte was imaginative enough to realize that scientific analysis alone could never accomplish this, that the artist and the man of letters must coöperate with the thinker in making positive sociology palatable. He recognized, too, with insight beyond that of the English Radicals of his day or the French *philosophes* of the preceding generation that no mere change in social constitution could achieve much without a reformation of human nature. This was to be accomplished by means of a new religion, based upon positive scientific knowledge of man and the cosmos, and called "the religion of Humanity." It involved the worship of a "great Being," which being was the human race as a whole, the great men of the past, the hoped-for great men of the future, all rolled into one and conceived as having a single god-like personality.[6] Huxley thought this was like praying to "the generalized conception of a wilderness of apes." Mill called it a "fantastic decoration" upon the essentially utilitarian scheme of positivism, with much of which he was in full accord. Certainly it has fallen dead, almost stillborn, from the pages of Comte's "Treatise of Positive Polity" (*"Traité de politique positive,"* 1851-4) and his "Catechism of Positivism" (1852). Yet it is not silly nor ignorant; it is just what might be expected of one who knew his science, who decided in advance that religion is necessary and that it must conform with science, and who started out deductively to construct such a religion.

[5] Neff, "Carlyle and Mill," p. 203.

[6] This conception was not altogether original with Comte, having been approximated by Saint-Simon.

A strange feature of this system is the religious corporation which it presupposes, an immensely powerful body having complete control of education and of the spiritual life of the nation—a sort of mediæval "Catholic church without Christianity" as it has been called. It was in keeping with Comte's line of thought that government should be by experts, whether in the religious or the economic field. The great powers of the State should be wielded by a few public-spirited business men. Present-day Italy would, one supposes, awaken his deep admiration, for he saw no value in the inefficient procedures of democracy. "In Astronomy, Physics, Chemistry, and Physiology," said he, "there is no Liberty of Conscience." . . . Reason is to be the servant of humanity, not the master. . . . Eventually he slipped into a mysticism that was far from the positivistic attitude of his early work. He and his devotees frittered away much time and effort in defending this, the least valuable, least characteristic part of his theory.

It is generally admitted that he was not a remarkable scientist. He was well acquainted only with mathematics and astronomy, and he made no new discoveries in either field. The part of his "course" dealing with physical and natural sciences has been declared to be superficial and even faulty at times. His arrangement of the sciences, his law of the three states are not final, as he surely believed them to be, but they are suggestive and stimulating; they do good service in counteracting the tendency of scientific specialists to become insulated within their own small provinces of thought. His great contribution was the invention of sociology. Before his time, a highly conventional economics was all the social science that was known.

As a writer, he certainly would not have qualified for the work of convincing men's emotions as well as their intellects. Even the thinking part of man might, like

Mill, be "suspicious of the neatness of Comte's generalizations," and the imagination could hardly be captured by his "manner heavy, labored, monotonous, without relief and without light"; now and then he uses "an energetic phrase, but as a whole the vocabulary is jejune; the sentences are overloaded; the pitch is flat. A scrupulous insistence on making his meaning clear led to an iteration of certain adjectives and adverbs, which at length deadened the effect beyond the endurance of all but the most resolute students. . . . [He] wrote with opium upon a page of lead." [7] Huxley said of Comte that "his works are repulsive, on account of the dull diffuseness of their style." Yet Comte's writing had one great merit: it was quite clear. "It attracted Mill by the cool logic, the clarity, the conciseness of its manner, which contrasted so markedly with what Mill then considered the 'insane rhapsody' of Carlyle." [8] The same critic whose objections we have quoted at length calls it "impressive . . . by reason of the magnitude and importance of the undertaking . . . sheer strength of thought." Despite the powerful opposition that rose against his ideas, it is not likely that they would have expired so completely as they have done, had not the theory of evolution given a new direction to thought, a direction gladly followed by Herbert Spencer, who disagreed with Comte from the first and was eager to supply his own synthesis of all science, his own philosophy of all thought and life, much influenced by Comte's yet definitely unlike it.

Meanwhile, however, England was under the spell of an older, more comfortable conservative doctrine, best represented by Dr. William Whewell,* the majestic Master of Trinity College, Cambridge. A man of mathematical mind, yet a theologian and something of a politician and administrator as well, Whewell shows in his work the

[7] "Encyclopedia Britannica," 9th edition.
[8] Neff, "Carlyle and Mill," p. 200.

* (1794-1866.)

cold, logical accuracy, the formal recognition of Divine power, the suspicion of novelty and of radical change, the somewhat pompous dignity, the imagination both spurred and curbed, which, curiously combined and blended, are the expression of his many-sided personality.

Whewell was an excellent mathematician. Had he not excelled even in schoolboy days in this subject, it is quite possible that he might have followed his father's trade of carpentry. But he won a scholarship and went to Cambridge, where he became Second Wrangler (in 1816), Professor of Mineralogy (1828-1832), and Master of Trinity College (in 1841). For a time he held the chair of what was strangely entitled "moral theology and casuistical divinity." His influence did much to introduce scientific studies into the curriculum, though on the whole his half century of university administration was most conservative. Thus he opposed the admission of Dissenters to the university, and upheld the system of clerical fellowships. His original work in science was limited to a series of investigations on the density of the earth—in collaboration with Sir George Airy (in 1826-1828)—and a "Mineralogical Classification," which was published in 1828. Quite early in life (1819) he prepared a model textbook, an "Elementary Treatise on Mechanics." In connection with his later professorship, he wrote another text, the "Elements of Morality Including Polity" (1845). He was chosen by the executors of the estate of the Earl of Bridgewater to write a volume on "Astronomy and General Physics" (1833) as a manifestation of "the Power, Wisdom, and Goodness of God." He performed this task to the satisfaction of all concerned, though his book is not an exact treatise but a general discussion of all sorts of things and though he took a very moderate position on theological matters. Said he, "Our purpose on this occasion is, not to show that Natural Theology is a perfect and satisfactory scheme, but to bring up our

Natural Theology to the point of view in which it may be contemplated by the aid of our Natural Philosophy." Along with consideration of the length of the year, the size of the earth, the ocean, climate, heat, electricity, sound, light, ether, and the Solar System, Whewell includes a set of religious views.

From this it must be evident that his learning was extensive rather than specialized. Naturally enough, the greatest, most typical of his works are two huge treatments not of any one or two fields but of *the* inductive sciences as an entire group. First came the great "History of the Inductive Sciences from the Earliest to the Present Time" (first edition 1837), of which he said, "my office is like writing the story of Columbus while he was still sailing westward." Conscious of dealing with a living study, he rises to the importance of the occasion, yet, with characteristic caution, avoids saying anything at all about the sciences, such as organic chemistry, that were still new. The work is divided into eighteen books, which tell the story of the sciences from Greek times down so closely to his own that each successive edition added supplemental notes on the progress of science since the preceding issue. There is a lengthy introduction in which Whewell amply exhibits his own viewpoint of the matter. The history of science has been "a long continued advance; a series of changes; a repeated progress from one principle to another. The earlier truths are not expelled but absorbed, not contradicted but extended; and the history of each science, which may appear like a succession of revolutions, is, in reality, a series of developments." Each great epoch has resulted in a typical generalization. "Our narrative, therefore, will consist mainly of successive steps of generalization."

Whewell respected generalizations; he adored induction. We find him describing the Dark Ages as a period when men had few distinct general ideas; we mark him

expounding that "during stationary periods . . . men . . . employed themselves in reasoning from principles. . . . This process . . . of Deduction . . . has no value when the fundamental principles, on which the whole of the demonstration rests, have not first been obtained by the induction of facts, so as to supply the materials of substantial truth. . . . From a pictured hook, we can hang only a pictured chain."

Such ideas are enforced as the history of science is traced. In the light of more recent histories, Whewell's, despite its vast bulk, seems superficial rather than thorough; despite his reiterated insistence upon the value of induction, it appears to give us the generalizations that are based upon inductive thought rather than the detailed facts from which a generalization may be induced.

Naturally enough, this book was followed (in 1840) by "The Philosophy of the Inductive Sciences, Founded upon Their History." This is intended as the "moral" to his history, as an application of Bacon's plan in the "Organon" to the state of science as it was in Whewell's own day. Like Bacon, he sought a single principle common to all advances in science—and found it in the inductive method. For this quest, Whewell evaded all doubtful matters, studying only those fields "in which the truths established are universally assented to, and regarded with comparative calmness."

In plan, the "Philosophy" is even more sweeping than the "History." It is divided into two parts, and these again into several books, each of which is subdivided into chapters. The first book deals with "ideas in general." Each succeeding book covers one particular science characterized by a special idea. Thus the "pure" or mathematical sciences express the ideas of space and time; the mechanical sciences are embodiments of the idea of cause, the philosophy of morphology (including crystallography) of the idea of symmetry, while the clas-

sificatory sciences are imbued with the idea of likeness. In Book 10, which deals with "palætiology," certain religious questions are discussed; and Whewell repeats his favorite doctrines that "Scientific views, when familiar, do not disturb the authority of Scripture" and that "there must be a First Cause."

The "Philosophy of the Inductive Sciences" thus takes up metaphysical and disputed theories, illustrating them by means of scientific examples. The book also seeks to explain in part how the mind works in its approach to the separate problems offered by each science; it is thus a sort of investigation into the psychology of the inductive sciences as well. Besides that, it is an organization, a synthesis or integration of the total corpus of scientific thought. In its systematic marshalling of whole groups of individual fields of study under some one general heading, and this in turn shown in its relation to other whole groups—in its grasp of the underlying *ideas* as the secret of arrangement among the sciences—Whewell's work reveals the power and dominating quality of the writer's mind. If he had not been a thinker, he might have been a great military organizer. He did manage incidentally to be a considerable academic organizer. The force, the commanding, regulating dignity and even majesty of his nature have been commented upon by several who knew him. Leslie Stephen [9] pictures him as he appeared to Cambridge undergraduates, strong and tall, harsh, stiff, unyielding yet magnanimous, while Darwin says that [10] "Next to Sir J. Mackintosh he was the best converser on grave subjects to whom I ever listened." He manipulated groups of sciences as Napoleon manœuvred army corps, and, one may suppose, with the same daring as well as with the same breadth of scope. Like most men of orderly minds, he was a conservative, and this accounts for his caution in facing the theological

[9] "Some Early Impressions." [10] "Autobiography."

implications of scientific thought. It explains also why he is so little known today, considering how highly his contemporaries honored him. "His fame has declined, partly because the advance of science has inevitably made his chief book antiquated, while philosophy, if it has not advanced, has at least deserted his position."

Another person, once famous but now almost forgotten, was Mrs. Somerville,* whose ambitious work "On the Connexion of the Physical Sciences" (1834) belonged in its day on every library science-shelf and on the reading-tables of many ladies as well. Daughter of an admiral, wife of a physician, she came naturally by her unusual abilities and interests, studied mathematics in secret, and devoted her life to the task of rousing similar interest among her sex. The great mathematical astronomer, Laplace, called her the only woman to understand his works. Touched by the compliment to herself, yet stung by the slur upon her sisters, Mrs. Somerville set to work to translate and adapt the great Frenchman's "Mécanique Céleste" for the comprehension of Englishwomen. Her version was planned for publication by the Society for the Diffusion of Useful Knowledge; when it grew too big for that use, she persevered none the less. Murray published it under the title of "Mechanism of the Heavens" (1831), and it took its place among astronomical texts.

As finally worked out, the "Mechanism" is scarcely a feminine or even a popular book. The "preliminary dissertation" has perhaps the greatest general interest, for it discusses the basis of knowledge and the wider implications of such vast forces as gravitation. The rest of the book is a regular and heavy text with definitions, axioms, graphs, formulæ, whole pages of calculation on the orbit of Jupiter or the moon, which call for intense application as well as considerable previous knowledge of advanced

* (1780-1872.)

mathematics. There are stretches, too, written in the cool and dignified philosophical tone of the day.

More definitely popular in style is her later and greater work, "On the Connexion of the Physical Sciences," a book dedicated to the Queen and designed to "make the laws by which the material world is governed more familiar to my countrywomen." Properly speaking, this book does not fall within any one field. The author states that "in all [sciences] there exists such a bond of union, that proficiency cannot be attained in any one without a knowledge of the others." Yet it is evident that she has in mind only the physical sciences proper; unlike Whewell she does not even mention the natural sciences, nor does she approach the mental and social studies so essential to Comte's scheme. One might even limit this book's field by entitling it physical astronomy. Astronomy calls both mathematics and physics into play, as well as direct observation of celestial phenomena. In attempting a picture of conditions in the sun, the moon, the stars, and the planets, including our own, the author commandeers the several sciences that assist in understanding general mechanics and astronomy, the constitution of matter, the atmosphere, sound, light, heat, temperature, climate, electricity, magnetism, electromagnetics, the comets, the stars, and even astrochemistry.

There is more conscious literary art in this than in her other book. It includes such clearly visualized items as this: "Our planet is flattened at the poles and bulges at the equator," but there is little, if any, really imaginative quality. The style and diction are on the whole lofty and formal, with the formality of the public lecture rather than that of the classroom or that of the specialists' academy.

But beyond and above all others, Herbert Spencer, creator of the "synthetic philosophy," is the type and the best representative of a single-hearted synthesist. Not

himself a scientist at all, in regard to technical or original achievement in any branch of science, but a thinker along metaphysical lines, Spencer assailed and overcame many branches of learning sufficiently for his own purpose—to put each into its own place in a scheme of cosmic knowledge that was no smaller than the universe. He writes intelligently, logically, often very artistically on physics, metaphysics, logic, education, chemistry, biology, anthropology, philology, psychology, sociology. His knowledge of scientific method seems to have been derived from ten youthful years of work at railroad engineering; but he left that practical career early and became intensely interested in governmental matters. The economic and political theories of the radical group that founded the *Westminster Review* had a fascination for him, a fascination which is illustrated by his refutations of them as well as by his adoption of many of their attitudes and methods. So, too, he was gripped by the overweening ambition of Comte's attempt to revise life, knowledge, and philosophy from the ground up. His associates—John Stuart Mill, George Eliot, George Henry Lewes, Harriet Martineau—were all more or less Comtist. Lewes went the furthest in frankly hailing Comte and his work in extravagantly hopeful terms, but even Spencer himself found it necessary to write a detailed article to point out specifically how and why he differed from Comte; people were seeing in him merely a disciple. Perhaps he had been a devotee once, and the bitterness with which he disavowed that old attachment is simply evidence of his eagerness to get rid of his past. He had his own synthesis to make; Comte must not obstruct it.

Spencer's works fall necessarily into two periods, and the dividing line is drawn by the publication of Darwin's "Origin of Species." Spencer went to some pains to show that what eventually and finally his system of

philosophy became was all implicit in writings of his actually published before 1859. It has been shown above, in the chapter on early evolutionists, that Spencer had been an aggressive Lamarckian in 1852. His "Principles of Psychology" had appeared in 1855, and even the General Doctrine of Evolution had been given to the public in an essay on "Progress: Its Law and Cause" two years before the "Origin." Perhaps he might have become the evolutionary philosopher even without Darwin's aid. But the great force of his philosophy grew from the fact that his metaphysical ideas were based upon sound science; if evolution had remained what it was in 1852—just another unsubstantiated theory—a great system of thought based upon the idea of evolution could not have won much adherence. On the other hand, with evolution in the physical world an accepted and all but demonstrated belief, any system of philosophy which was based upon it must have been respectfully listened to.

Spencer was more interested in social phenomena than in natural history. His early works are mostly social. As a thinker, he recognized the need of science in any consistent picture of the universe that hoped for acceptance in a modern world. To prepare such a picture he had to familiarize himself with science, and his great mental fertility lent itself well to this necessity. His earliest training, remember, had been as an engineer. Accordingly his mode of thinking throughout life was logical, abstract, mathematical, mechanical—even when dealing with the very un-mechanical phases of the sciences that treat of life and society. His aim was "to interpret the phenomena of life, mind, and society in terms of matter, motion, and force." There must be, he reasoned, some one great principle, some single dominant tendency that rules or at least that points the direction of everything which happens in the universe. It must be a principle so abstract and so general that it applies

equally to the formation of snow crystals among the clouds of the upper atmosphere and to the formation of joint-stock corporations with limited liability in the neighborhood of Leadenhall Street in the City of London . . . and to all the phenomena between. This principle he found in evolution, not, like Darwin's, a mere explanation of a comparatively limited phenomenon such as the formation of species of plants and animals, but literally of everything of which it is possible for man to have knowledge.

By 1860 he was ready to devote his life to the great mission of producing a coherent scheme of knowledge based upon the one principle. But a man must live. We have seen how he first approached John Stuart Mill, then an official of the East India Company, requesting a position, something with merely nominal duties such as would leave him much free time for thought and writing, and with a stipend sufficient for his "modest bachelor requirements." In short, he had to be maintained, perhaps for years, while working out his great scheme. The East India merchants apparently did not see profit in the suggestion. At any rate Spencer soon changed his tactics. He issued a prospectus, calling for persons to subscribe in advance to a series of works which should treat the synthetic philosophy. In this prospectus he outlined what the remainder of his life was to bring forth—a succession of volumes discussing various sciences from the one viewpoint of evolution. He promised a certain number of volumes and stated how soon each might be expected, very much as a bank or an insurance company promises interest and dividends to its stockholders. Strangely, he did get enough advance subscribers to make the production of a system of synthetic philosophy possible without starvation; more strangely still, he did produce volumes at the stipulated rate. Eventually the shelf was filled. Each branch of knowledge was represented

by a book of one or more volumes of "principles," a book not very serviceable as a text for the study of beginners who need the facts of the science, but as a set of deductions and inductions drawn from wide knowledge and incisive thinking within the field, a good book to be read by those who already know much about the subject it treats.

The first of the set to appear was, reasonably, "First Principles" (1862-1867). This study of the basic foundations of knowledge has been discussed above.[11] It will be sufficient to point out here that Spencer was charting the realms of the Absolute, seeking and stating general truths that would apply alike to all provinces of knowledge. Says he,[12] "These truths, holding of existences at large, were recognized as of the kind required to constitute what we distinguish as Philosophy." Existence at large, like the "transcendental physiology" which he had outlined in an earlier essay, was the meat upon which he grew great. Thus, after expounding in Part I the "unknowable" which is the proper sphere of religion, he approaches the "knowable"—in Part II—the proper sphere of science. It is here that the grand principles of transcendental physics are laid down: the Persistence of Force, the Continuity of Motion, Evolution and Dissolution,[13] the Instability of the Homogeneous.

It is indeed a majestic picture that Spencer gives. Behind the Maian veil of natural manifestations lies an inscrutable mystery, which, if you wish, you may believe to be a personal, omniscient, and loving God. But our business does not lie there. What we may know is a world of matter, which is indestructible, and of force, which persists for ever, though its form and direction may change. Simple, homogeneous matter is unstable; as each force acts upon it, matter is constrained into more

[11] Chapter XV. See also Chapter X.
[12] "First Principles," p. 496.
[13] One cannot get the true Spencerian flavor without capital letters.

and ever more complex, more heterogeneous forms. This is the General Doctrine of Evolution, a process which he defines as "an integration of matter and concomitant dissipation of motion; during which matter passes from an indefinite incoherent homogeneity to a definite coherent heterogeneity and during which the retained motion undergoes a parallel transformation." Of course this process of building must some day reach a limit, and then dissolution will set in. When matter is once again incoherent and homogeneous, evolution will start once more; and this rhythm of making and unmaking will proceed, world without end, on and on.

Such are (very crudely summarized) the first principles under which Spencer was to marshal and regiment all of man's knowledge. It became a scientific necessity to write the other books which should illustrate the specific action of these principles in the various fields. But then the question arose as to what those various fields may be. To define his own ideas upon this matter, he wrote an article on "The Classification of the Sciences," perhaps the key to his entire system. Classification at once brought him into conflict with the similar attempt of Auguste Comte. Indeed Auguste Laugel, writing in *La Revue des deux Mondes,* described Spencer as an unconscious follower of Comte. This aspersion had to be answered; today the answer is appended to the article on classification, and rightly. Spencer shows best what he thinks by showing what it is that he does not think. Both his natural disputativeness and his logical faculty for drawing fine but sharp distinctions make this an effective and useful method of exposition.

Comte, be it remembered, arranged the six sciences in a series. Spencer regards a serial arrangement as deceptive, almost dishonest. He divides them primarily into two families—"those which deal with the abstract relations under which phenomena are presented to us,

and those which deal with the phenomena themselves." Most abstract of all "and dealing as they do entirely with the relations of coexistence and sequence, in their general or special forms, Logic and Mathematics form a class of the Sciences more widely unlike the rest than any of the rest can be from one another." Comte, it seems, failed to realize that *abstract* and *general* are not the same thing; and to Spencer this is a vital distinction. "Abstractness means *detachment* from the incidents of particular cases. Generality means *manifestation* in numerous cases." Some abstractions are general or universal, some not.

The sciences, then, are either purely abstract, abstract-concrete, or entirely concrete. The first group has been described, those in the second group aim at "analytical interpretation" and "are primarily divisible into the laws of force considered apart from its separate modes, and laws of force considered under each of its separate modes." The concrete sciences aim at "synthetical interpretation." He even predicts a new science—"universal concrete science" he dubs it—whose function shall be to generalize statements about phenomena themselves. Such a science, if it ever existed, would be in exact opposition to the Comtian dogma.

Spencer differs, further, from Comte in refusing to admit that there are three separate stages in the development of any science. To his mind, all development is essentially the same—toward heterogeneity. Unlike Comte, he thinks that natural law is more than a statement of sequence, that some things do cause other things. In sociology, he will not admit the force of ideas; society responds to character, not to thought. In biology, he holds evolution and the study of species to be "the supreme division," whereas Comte thought species immutable and therefore not worth studying. Again Comte advocates the worship of Humanity, Spencer "the un-

known source of things." In political theory Comte favored a sort of socialistic paternalism; Spencer believes in *laissez-faire*. Not Comte, but Von Baer, is his acknowledged inspirer.

It is thus seen that his classification of the sciences is more logical than useful. It does not correspond to a division of the sciences as they actually are nor as they were in his day, but to an ideal condition which may exist when sciences are classified according to transcendental first principles. If there is to be a hierarchy of sciences, a ranking of sciences, some higher and some lower, Spencer would place those of widest intellectual application at the top. For example, there can be no field in which the axioms of mathematics and logic are false or irrelevant; hence these two abstract sciences are the fountainheads of all others. Geology, on the other hand, is made up of all sorts of special cases, which often do not apply outside their own single stratum of earth's crust; hence geology is a science far inferior to mathematics. The more abstract, then, the more important a science is to be considered.

From the literary viewpoint this is an unfortunate conclusion. We have seen how greatly human interest is aroused, how gloriously literary art is aided by concreteness, how these desirable qualities are thwarted by too much abstraction. Too much abstraction became one of Spencer's vices. He knew how to write with verve and vividness. When aiming to reach the public, or when treating of subjects with much of the pictorial in them, Spencer could and did make his work as replete with specific, vital illustration and visualizable reality as anyone could wish, but when he wanted to dumbfound the world with the profundity of his system, he swung to the opposite extreme, wallowing in abstract thought and in elaborately technical language. This he did even in his "Principles of Biology" (1864-1867), the next part of the

series to appear, though this book deals with one of the concrete sciences. It is really an enlarged version of his early essay on "Transcendental Physiology"[14] in which he seeks general laws that hold "of all organisms." Thus he goes back to organic matter and the action of forces upon it. He goes into detail in describing the theoretical reactions of a theoretical "monad," as abstract and unreal a creature as the "economic man" of the early economists. The book is significant chiefly as a careful, intelligent, courageous application of the Spencerian philosophy to a definite, objective science. Unlike the general run of philosophers, Spencer was not content to solve the universe as if it were a mere intellectual problem that need never be checked up by comparison with the vulgar facts of everyday experience. The first principles, which in theory should apply to all sciences, are here shown applying to one particular science. It was this science, furthermore, which had shortly before been reformed by Darwin's introduction of the principle of evolution; here Spencer could most fittingly apply his General Doctrine of Evolution.

Even before planning a series on the Synthetic Philosophy, even before the "Origin of Species" appeared, Spencer had written and published a book on "The Principles of Psychology" (1855) which is his best evidence of priority and originality. He rewrote and reissued this book as the next part of the series (1870-1872). Here, too, the principle of evolution is seen to apply to the formation of man's mind and spirit; *intuition,* that stumbling-block of the early, logic-minded free-thinkers, is explained as inherited experience.

Another old book that was dug out of the barrel and revamped in the light of the newer viewpoint was his "Social Statics." This book, first published in 1850 with the subtitle, "the Conditions essential to Human Hap-

[14] See Chapter X. For discussion of his "Biology," see Chapter XV.

piness specified, and the first of them Developed," was an attempt at treating social science quite like physics. That study, remember, is often divided into *statics*—the study of bodies at rest—and *dynamics*—the study of forces. In 1850 Spencer saw society mechanically, as a body at rest or acted upon by certain forces. In 1876 (and 1896) when "The Principles of Sociology" was added to the library of synthetic philosophy, he viewed society not mechanically but biologically. This time social growth is discussed as "superorganic evolution." There is a very thorough account of the primitive social state, from which present society is descended after a struggle for existence which has allowed the fittest social forms to survive and strangely has preserved some "vestigial organs" in the body politic as well. The analogy is traced in detail, the author even declaring point-blank that "a society is an organism." The book is more inductive than some of his others, for the general theory of sociology is not given until some of the phenomena of social action have been rather fully and vividly presented.

In 1892-3 he issued "The Principles of Ethics" which completed his exposition of the universe. So important did he consider this part of the work that he rushed its first section on "The Data of Ethics" into print before finishing the "Sociology." Here, too, he applied scientific ideas to a field often reserved for religion or custom. His data were definite facts as to what various nations and tribes regard as right and wrong—a crushing argument for one who believes in eternal principles of morality. Evolution plays an important part in the theory; Spencer is an individualist, declaring for a fair field and no favor to interfere with the struggle for existence. He assumes that the workings of evolution tend toward the greatest happiness of man.

Thus, with a determination and persistence unrivalled

in literary history, he wrestled with the problem of organizing all knowledge into a coherent system, laid down his ground plan, and lived to complete the structure. "No English thinker since Bacon and Hobbes had even attempted anything so vast. . . . Spencer's idea of philosophy is a system of completely co-ordinated knowledge—the sciences consisting of knowledge partially co-ordinated. In this sense his system is synthetic. It is a scheme in which everything is to find its place, and is to be seen as the resultant of a single principle." [15]

So much for the content of his works. His command of literary structure, his power of pungent argument illustrated by vivid scraps collected from everywhere, his oratorical periods and even more oratorical repetitions,[16] his determined plungings into thick, metaphysical, technical obscurity—all these have emerged in the various discussions of his work scattered through three of these chapters.

That he worked with conscious application to write well, we may conclude from the fact that he also prepared a suggestive little essay on "The Philosophy of Style" (1871) in which the same scientific, philosophical methods are applied to an understanding of the technique of literary composition as to other problems. Here he analyzes the "causes of force in language which depend upon economy of the mental energies and those which depend upon economy of the mental sensibilities." Through both parts of the essay and "underlying all the rules" Spencer stresses "the same fundamental requirement—economy of attention. It is indeed because they so well subserve this requirement that figures of speech are employed." Typically, he must state his conclusion in the form of a quasi-mathematical formula: "Other things equal, the force of all verbal forms and arrange-

[15] "Camb. Hist. Eng. Lit.," Vol. XIV, p. 31.

[16] See "Repetition in Public Address," by L. Crocker, in *Eng. Journal*, Vol. XVI, p. 7, Sept. 1927.

ments is great, in proportion as the time and mental effort they demand from the recipient is small. . . . The aim must be to convey the greatest quantity of thoughts with the smallest quantity of words." This must not be taken to mean that each idea should be only barely stated, for there is a second principle of economy of sensibility "that the sensitiveness of the faculties should be continuously husbanded" by means of striking expression, climax, anticlimax, variety, antithesis "to prevent the continuous exertion of the same faculty" and the resultant bored fatigue. He realized also the value of using concrete words and clear arrangement.

When he wished to, Spencer wrote successfully according to the methods suggested. Darwin often praised him for excellence of style and argumentative brilliance. Often, however, he felt somehow suspicious of Spencer's uncanny facility. At least once he said that the philosopher's style was "too hard for me" [him] admitting its power to "impress my [his] mind with the idea of his inexhaustible wealth of suggestion, but never convince me."

A reading of critical articles—indeed of philosophical articles of almost any kind—in the eighties, nineties, or in the early years of our century shows how far Spencer's fame has fallen off since then. His perfectly rounded, reason-satisfying generalizations and abstractions no longer impress the mind with the sense of reality and finality that they once had. In comparison with the radical thinkers of the post-Nietszchean epoch, his liberalism is fairly tame, almost conservative; while Bergson, with his "creative evolution" idea and his doctrine of an *élan vital,* seems to attract the imagination more than the Spencerian notion of a march toward heterogeneity and an ultimate Unknowable.

Be that as it may, during the last few decades of the nineteenth century, Spencer was more than just another

scientific thinker, more even than just a very great scientific thinker. He was the fountain-head of wisdom for a large, enthusiastic, and thoughtful public. Many a young man of today was named in his honor. Many a brilliant journalist, orator, liberal clergyman adopted Spencer's views and devoted an active lifetime to spreading that gospel. There was a Spencerian school of thought, stronger in the United States even than in Great Britain. Among its members two of the most active were Henry Drummond (1851-'97) and John Fiske (1842-1901). Neither was in the true sense a scientist; indeed all the most active Spencerians were drawn from non-scientific fields. Drummond was a minister of the Scottish Free Kirk, that interesting organization that also claimed Thomas Chalmers and Hugh Miller. For years he lectured on natural history and theology in a denominational college in Glasgow. For scientific purposes he engaged in expeditions that took him to the Rocky Mountains and to Africa, expeditions that led to his books of "Travel Sketches" (1890) and "Tropical Africa" (1888). He organized a missionary movement among college students that had reverberations in all the continents. But above all Drummond was a reconciler. In the philosophy that was based upon evolution he saw a fresh means of showing the perfect consistency of religion and science. He regarded some of the conclusions of evolutionary thought as direct or indirect proofs of the existence of a wise Providence and an ultimate moral law in the universe. This particular theme supplies the text of his long (full volume) sermon, "Natural Law in the Spiritual World" (1883). He poses a strange question, "In a word is the Supernatural natural or unnatural?" and proceeds to answer it by showing the application of natural law to moral matters. In this he differs from all earlier reconcilers, who sought analogies between the two kinds of truth in individual phenomena; he seeks analogies in

law. For instance, he cites the newly established case of biogenesis. This long-disputed question has at last been settled; all life comes from preëxisting life. So, too, says Drummond, "spiritual life is the gift of the Living Spirit." Or again, take the established matter of degeneration; man, like beast or plant, reverts to the lower type from which he rose as soon as the effort that raised him is relaxed. It is a hopeful book, not scientifically important.

Another, better known volume is Drummond's "The Ascent of Man" (1894) whose very title shows how and in what sense the author had accepted Darwinism. It is a supplemental work to "The Descent of Man" in that it begins where the other left off. Taking man as evolved, it attempts to trace the growth of civilization by reference to a principle of "struggle for the life of others." The influence of Darwin, Spencer, and Fiske is evident in the line of thought, and Wallace's dictum that the soul is not a product of the struggle for life is mentioned. The human family, with the mother sacrificing all for her helpless young, is the basis of *altruism*, under the influence of which human society, human coöperation, all progress have come into being.

John Fiske (at first named Edmund Fiske Green) was an American who, with tremendous industry and energy, produced in a comparatively short life a great number of books on historical and philosophical subjects. Early in life he tried to still his yearning for a comprehensive interpretation of the universe by means of Comte's positivism. Like Spencer he found this an unsatisfying diet, but, soon happening upon Spencer's more scientific, more realistic interpretation, he became a whole-souled exponent of that system. As professor at Harvard, Washington University (St. Louis), the University of London, and the Royal Institution, he managed to get a hearing for his version of Spencerianism. Much of his writing is made up of lectures revised for the press. Apart from

his eleven volumes of essays upon American history, Fiske's principal works are these: "Outlines of Cosmic Philosophy" (1874), "Myths and Myth-Makers" (1872), an anthropological, religious study, "Darwinism and Other Essays" (1879, revised 1885), "Excursions of an Evolutionist" (1883), "The Destiny of Man Viewed in the Light of his Origin" (1884), "The Idea of God as Affected by Modern Knowledge" (1885), and "A Century of Science" (1899).

The greatest of these, both in size and in scope, is the "Cosmic Philosophy," in which Fiske, with a lucidity that Darwin and others contrasted with Spencer's customary style, expounded his master's theories. Yet he modified them to suit his own viewpoint. For instance, Fiske called his body of doctrine "Cosmic" philosophy rather than "synthetic," that it might connote an orderly, law-governed universe. It is synthetic, of course, but to Fiske's mind the fact that it is cosmic is a far more essential one. Like Spencer he admitted the existence of an ultimate "unknowable," which he honored as reverently as though he had frankly called it God. Note, however, that he insisted on the greater truth of a "Cosmic Theism" as against the more ordinary "Anthropomorphic Theism" and felt that "deanthropomorphization"—terrible word—was an intellectual necessity. Like Spencer he employed a great deal of mere abstract logic; like him, too, Fiske began his system with a study of the relativity of knowledge, proceeded by way of the scope of philosophy, through questions of causation, on to an evolutionary synthesis. An interesting, though wholly unoriginal, section summarizes Darwin's work in accounting for the evolution of living forms. A vital discussion centers about what the meaning of "free will" can be if there is such a thing as social science. Eventually the author reaches the topics of the evolution of mind and the evolution of society. With the gusto of the born debater,

Fiske joins issue with whosoever seems to him in error, notably with Comte and with Froude for his dictum that history is not and cannot be a science.[17]

In this big book, Fiske is perhaps too largely the voice of his master. Though he does modify the doctrine in parts, we do not feel all of the man's own freedom of personality, such as is evident in his other works. Fiske was an exceedingly busy person, lacking the leisure to perfect a work of such size and still to express himself. Much of his writing is vivid. Certainly he has retold in four volumes all that is essential in the entire life-work of Spencer. Yet even at that he is not wholly at ease in it; there are thick gobs of too Spencerian abstraction, told not as one might expect of Fiske but rather as if borrowed in bulk from Spencer. The American was more at home in briefer studies with a more direct moral and religious appeal, with less need of ploughing up the ultimate and sowing the absolute in the unknowable. Especially was he happy when he could combine a gentleman's knowledge of geology and botany with an historian's knowledge of primitive man and present both in the graceful oratorical manner that must have been especially satisfying when heard coming from his own lips.

There is, for instance, his "Excursions of an Evolutionist," a series of separate essays, loosely joined by a vague chronological sequence. Here the author traces the supposed history of the human race from the geological record, and what might be called the philological record—the evidence of language—through the Protestant Reformation and on to "a universe of mind-stuff" and an appreciation of Charles Darwin, all of it written in his usual clear and melodious style. Again there is "The Destiny of Man" which follows the theory of evolution from the physical plane into the social. The author

[17] James Anthony Froude, "The Science of History," in "Short Studies on Great Subjects," 1868.

shows plainly how the idea of evolution, far from reducing man to the level of the brutes, vastly increases his dignity and importance, how civilization has resulted from, and how it now works to limit, the process of natural selection. Part of the volume consists of "an epitome of [his] own original contributions to the doctrine of evolution." These original contributions are: first, the importance of human infancy, so unlike that of the beasts, and its vast influence upon the possibility of progress; second, the importance of industrial civilization in eliminating warfare; the rather arbitrary dictum that "on the Earth there will never be a Higher Creature than Man," for his great evolution has been of the mind. The last three chapters form a sort of reversal of the very realistic attitude of most of the book; here the appeal is rather to faith than to objective and rationalistic science, and several conventional religious views are upheld without proof. It is largely presented in the historical order, and the style is notable for a pellucid loftiness, from which the author now and again descends, with a little loss of dignity, into wit. The sweet hopefulness of his approach to the problems of life and mind is, as ever, refreshing.

"A Century of Science" had an auspicious occasion. Fiske had been asked to speak at the exercises commemorating the centenary of the foundation of the First Unitarian Church of Philadelphia. It had been established by Dr. Joseph Priestley, the unhappy discoverer of oxygen, who spent his last years in denying that there could be such a thing as oxygen. Priestley had been a minister as well as a chemist; he was a case in point for Fiske's favorite idea of the complete compatibility of what he called "aspiration and knowledge." The first essay traces with urbane dignity the growth of the sciences. The remainder of the volume adds little that is new. Fiske was for science—especially of the evolutionary sort—

what Longfellow was for poetic culture: a suave and gifted interpreter speaking to the American public for his branch of learning.

A less famous but more modern, more fundamental analysis of the basis of scientific thought is Professor Karl Pearson's "The Grammar of Science" (1891). Professor Pearson, who is both physicist and sociologist, who has held professorships in mathematics and in eugenics and who was called to the Bar, approaches his problem armed with the rigorous methods of exact science but always bears in mind that the ultimate justification of science will be found in its contribution to the life of the community. He states the aim of science as the study of what is reported to us by our senses; he emphatically rejects any assumption that what is thus reported must correspond with an ultimate reality. Thus he can readily answer those who see in the progress of science a revolution or a series of revolutions, the false doctrine overturned by the true. We have no proof that the later doctrine is actually true. All we know is that it resumes more of our *precepts* within a *concept* than the earlier could do and thus is, so to speak, *truer*. Scientific law is merely a brief statement or formula summing up such facts in a description of phenomena. Space and time, he holds, are both unreal, mere modes of thought. Motion is never absolute but always relative to some other motion. Matter is merely our way of "conceptualizing the routine of our sense impressions." Newton's famous laws of motion are retold in skeptical mood, with all the reservations implied by these strange conclusions. Life can be understood best if it is studied according to the attitudes and principles of physics. Such study has shown the immense advantages of evolution over any other theory of life yet devised. The book concludes with a classification of the sciences based upon Bacon, Comte, and Spencer: the sciences are divided into the Abstract,

the Physical, and the Biological, and these in turn "are united pair by pair by Applied Mathematics and Biophysics." [18]

Pearson writes vigorously despite his ultra-philosophical insistence upon difficult terms that he conceives to be necessary to honest presentation. He has little patience with those who seek to reserve certain portions of the universe, who say that science can go so far, but that beyond a certain point lies the legitimate field of intuition or revelation. Science, he holds, is not a subject-matter but a method of study—the only one by means of which it is ever possible to *know* anything. Metaphysics arouses his outspoken contempt, though he recognizes that much of physics is couched in metaphysical formulæ. His work differs from that of most of the men who have attempted syntheses of the scientific map of the universe in that he is a real expert in what might be called field-science; that is, science at work, within two of its provinces. What he says has a more solid ring—as well as the authority that comes from being a later, more sophisticated product. It is not so majestic as Spencer's, not so significant to the human race as Comte's would like to be, not so confident of the future as Fiske's, but (to use a word that Professor Pearson might object to) it seems to be *truer* than any of the others.

[18] For an original classification, based on psychological approach, see Chapter I.

CHAPTER XXI

POPULARIZERS OF SCIENCE

Doubtless most persons hearing of scientific *literature* would at once take it to be quite identical with what is often called "popular science"—that is, with writings whose sole object is to restate the discoveries of the specialists in such form that it can be understood, even enjoyed, by the man in the street. A good many scientists rather look down upon all such predigested, unduly simplified presentations. With these two widespread assumptions in mind, certain questions were included in the questionnaire sent to several leading scientists and other scholars,[1] upon which a part of this study is based. Question 10 asked: Do you consider that, generally speaking, works of so-called "popular science" are undependable? The answers were rather scattering; eight persons replied in the affirmative, six in the negative, and four gave qualified answers. One declared it unwise to generalize, one thought such books "not always, but frequently" guilty of the charge, and another estimated that "about four out of five are undependable in spots"; a biologist thought that popularizations are undependable "in biological fields." Perhaps the fullest, most thoughtful answer was, that of the chemist and historian of chemical progress who declared: "Not always, by any means, but any simplification is partial falsification."

The question ought perhaps to have been worded more exactly. As it was, it allowed room for much expression of vague and general opinion. The results are interesting

[1] See Introduction, also Appendix.

in that they show a widespread divergence of opinion, that might be summed up in the rather obvious formula that some works of popular science are good science whereas some others are not. The next step is to select those that are thus approved and study their literary qualities and the technique of their presentation. This is a vast subject, from the critic's viewpoint full of interest. Since the books in this group were written to be read by persons who are not specialists, whose interest must be caught and held, they may be presumed to be more truly literary than many of the scientific classics, aimed as these often are at the writer's professional peers whose interest does not have to be wooed and who are more likely to be impressed by formidable arrays of cold figures than by an attractive style. But it is interesting to discover whether any scientists themselves have been impressed notably by popular versions, so Question 11 asked: Do you know of any particularly fine books of "popular science"? Please give names. The answers formed a considerable bibliography, not all of it serviceable for the present discussion. They served, however, as a sort of recantation or qualification of the statement implied in answers to Question 10 that popular scientific works are undependable. Nine replies maintained that position, yet only one failed to name any book as particularly fine. Five replies mentioned Huxley's essays, three named Tyndall's essays, and three Dr. de Kruif's "Microbe Hunters." The following received one vote each: Mach's "Popular Science Lectures," Faraday, Dr. Dorsey's "Why We Behave Like Human Beings," Dr. E. Altenburg's "How We Inherit," Professor Harrow, Humboldt, Darwin, Wallace (five of his books were named), Professor E. E. Slosson, "Creative Chemistry," John Mills' "Letters of a Radio Engineer to his Son," Professor J. A. Thomson, the Van Nostrand Series, Professor Eddington's "Stars and Atoms," Professor Percival

Lowell's "Mars, the Abode of Life," and Camille Flammarion. One referred to the American Library Association list given under the general title of "Reading with a Purpose." In general, the titles suggested seem to reflect the answerer's personal interests; many are contemporary, some (such as Darwin's) are not really popularizations, but taken as a group they do indicate that even a largely professional audience responds to writing that is intended to arouse interest by appeals to the common concern of humanity.

It is significant, too, to compare the lists given by each individual with the list given by the same individual in answer to Question 4,—What book (or books) of science stand out in your recollection as especially memorable?— Several persons picked the same books as "especially memorable" and as "particularly fine books of 'popular science,' " which seems to show that, like Darwin and the man in the street, these professional astronomers and biologists were (sometimes at least) more impressed by books with a popular appeal than by those nearer that kind of impartial truth that comes from not attempting to simplify.

To attempt a detailed critical history of scientific popularizations is far beyond the scope of this chapter. However, as books of that type form a significant and suggestive division of scientific literature, it is necessary to glance more or less hastily at some of its outstanding writings. By all odds Huxley leads the field. He combined in unusual degree those qualities of real scientific learning, real literary skill, and instinctive appreciation of the ordinary human point of view that made his authority respected and gave to his essays a wide public. The intense fervor with which he fought what he considered the battle of subjugated truth against despotic prejudice lent his work an especial value in its own day which the passing of a generation has diminished, but the lit-

erary quality of it appears to be permanent. To many readers the name of Huxley is very nearly synonymous with good popular scientific literature. A detailed account of his life and work having been given above, in the story of the battle over evolution, it may be omitted here.

The popularizers, of course, go back much further than Huxley. Old Ælfric, the first scientific writer to use Anglo-Saxon as a medium of expression, was a popularizer, for he adapted and simplified the easy Latin natural history of Bede for his unlearned readers. Chaucer, too, in writing his "Tretis of the Astrolabie," aimed at the intelligence level of his eleven-year-old son. Galileo's "Dialogues Concerning Two New Sciences" (1638), garbed as they are in dramatic externals, must have been meant less for the academician than for the man in the street or at least for the man in the villa and countinghouse. Joseph Addison, in writing his "Dialogues upon the usefulness of Ancient Medals" (1721 posthumous), likewise enters the array of popularizers. Robert Boyle (1627-1691), the discoverer of Boyle's law of the pressure of gases, dubbed by Sir Humphry Davy "one of the most active experimenters and certainly the greatest chemist of his age," followed Galileo's sort of popularization by means of the dialogue form in his curious book, "The Sceptical Chymist" (1661). During the same age, Sir Thomas Browne, strange, moralizing physician, gave the reading world his ingenious Gothic treatises on "Religio Medici"—a doctor's faith—(1642), "Pseudodoxia Epidemica; or Enquiries into Vulgar Errors" (1646), wherein the most absurd notions are sagely disproved, "Hydrotaphia; Urn Burial" (1658), one of the earliest rational approaches to archæological study. So, too, John Evelyn the diarist, who was a Fellow of the new Royal Society, wrote several rambling volumes: "Sylva, or a Discourse of Forest Trees," etc., etc. (1663-4), "Acetaria, a Dis-

course of Sallets" (1699), and others, in all of which he insisted upon experience as the basis of knowledge.

These are just a few of the adapters and simplifiers of natural knowledge who flourished before the beginning of the nineteenth century. There were others, some of whom will be mentioned under another heading and some of whom must be omitted for considerations of expediency. With the great scientific expansion of the years of Victoria's reign and the unprecedented interest in education that accompanied it, the golden age of the popularizer began. The Royal Institution was founded in the year 1800 by Rumford, a Massachusetts-born Yankee who became a Bavarian Count, and Sir Humphry Davy (1778-1829) became its Professor of Chemical Philosophy. His duties included both original research and the delivery of public lectures. Davy's discoveries were of prime importance; his invention of the safety lamp enormously reduced the hazards of mining. His lectures were brilliant social affairs and instituted a custom that has persisted.

Much of Davy's writing shows the influence of his habit of addressing general audiences. For example, his "Elements of Chemical Philosophy" (1812) is a students' text-book and, as such, might be expected to present cut-and-dried principles and facts according to an arbitrary and formal plan. The general structure of the book does follow this spirit in that it is largely deductive; it proceeds from the most general of generalizations to those less general and ultimately to the quite specific. Yet in style Davy uses the combined poetic and oratorical one that fitted him so elegantly upon the platform. His scattered technical reports, gathered into a volume under the name of "On the Safety Lamp for Coal Miners, with some Researches on Flame" (1818), give less room for rhapsody, but here, too, the frequent narratives of his experiments make easy reading with a human appeal. The only totally popular work of Davy was the child of

his old age, "Consolations in Travel; or, the Last Days of a Philosopher" (1831, posthumous). In this book the author's desire to be literary fairly runs riot. It is pompous and top-lofty in style, full of stale, late-Romantic symbolism, with a mystic personage called the "Unknown" who reasons elaborately from beautified geology to natural religion. Oddly enough it is here that Davy declares that "the chemical philosopher should adopt the simplest style and manner; he will avoid all ornaments as something injurious to the subject, and should bear in mind . . . that . . . tropes and metaphors . . . were like the brilliant wild flowers in a field of corn, very pretty, but which did much hurt to the corn." Davy can be understood by recalling that he belongs in spirit among the men of an earlier generation to whom fine writing must always be *fine*.

Davy was succeeded at the Royal Institution by Michael Faraday,* one of the most original and successful of discoverers, best loved of men. His life reads like some romantic fairy-tale of a poor but earnest youth who wins his place among the world's great. First permitted by Davy to do odd chores about the laboratory, he presently began research work of his own. His earliest papers were looked over by the baronet to remove serious faults in the use of English as well as to add some stylistic elegance. Yet he lived to be a lecturer of wide appeal, even to children. The greatest discoverer [2] in the field of electro-chemistry and magnetism, upon whose work the electric dynamo and motor and all the resulting development has depended, he was humble and pious all his days. With odd simplicity he preferred the title of "philoso-

[2] Faraday anticipated the now common, but even yet startling conception of atoms as "mere centres of forces or powers, not particles of matter, in which the powers themselves reside." In "A Speculation touching Electric Conduction and the Nature of Matter" (*Phil. Mag.*, XXIV, Feb. 1844) he writes: "The difference between a supposed little hard particle and the powers around it I cannot imagine," and "matter and atoms of matter would be mutually interpenetrable." *(1791-1867.)

pher" to any other—product of his essential lack of sophistication. It is little wonder that he could hit the level of the untrained mind, without stooping.

When he spoke or wrote, he attacked the problem directly, with few or no affected flourishes. Frankly he would expound the difficulty, trace the processes of his own reasoning upon it, narrate his experiments (including those that failed), lead the attentive reader or hearer along to his own conclusions. It was simple and it was sufficient, with just a suggestion of the old-school preacher's rustic dignity to keep it from being very attractive. A good many of his reports, gathered from the Royal Society's "Philosophical Transactions" and other periodicals, were reissued in 1859 as "Experimental Researches in Chemistry and Physics." He had previously published (1833) his "Experimental Researches in Electricity" and other special reports as well as a students' manual on "Chemical Manipulation" (1827). In 1861 his "A Course of Six Lectures on the Chemical History of a Candle" was made into a book after being delivered to juvenile audiences that gave up part of their Christmas holidays to come to the Royal Institution and hear him.

Indeed the reign of Victoria seemed to coincide with a vast expansion of public interest in scientific things. Lecturers who could explain so that the man in the street could understand were in great demand. This applied to many fields. Professor Gideon Algernon Mantell (1790-1852), a courtly savant like Davy, interpreted the geological advance "divested as much as possible of technical language to render it acceptable to the unscientific reader." He was one of those who helped to bridge the gulf caused by Lyell's new theories, which he greatly admired while holding that sciences aid in "proving the infinite power, wisdom, and goodness of the Great Cause of all things." He wrote self-consciously, with plenty of

rhetoric and some fine vivid description. His most famous books are: "The Geology of the Southeast of England" (1833), "Medals of Creation" (1854), "Contemplations of Nature," "The Wonders of Geology" (1838), "Petrifactions and their Teachings" (1851), and "Thoughts on a Pebble, or a First Lesson in Geology" (8th edition, 1849).

One of the very earliest books that awakened the infant mind of Charles Darwin to an interest in the meaning of nature was Robert Sears' odd compendium, "The Wonders of the World in Nature, Art, and Mind, comprising a complete Library of Useful and Entertaining Knowledge." This variegated outline of science, "illustrated with Several Hundred Engravings" and "compiled from the best and latest sources," modestly admits that "for comprehensiveness of plan" it "stands alone, and without a rival in this book-making age!" There is a bit of the showman's vulgarity about it, but it is interesting because of the width of its field of concern and because of its vivid, detailed, and spectacular descriptions.

Not entirely out of the same class is the work of W. Mullinger Higgins. There is, for instance, "The Entertaining Philosopher," whose subtitle will be sufficient description, for it runs thus, "a Familiar Explanation of the Most Interesting Phenomena of Natural and Experimental Philosophy, comprising a Store of Curious and Instructive Information in Mechanics, Hydrostatics, Pneumatics, Heat, Optics, Magnetism, Electricity, Galvanism, etc., Compiled to Promote Practical Education." Our grandparents had powerful mental digestions if this book deserves to be called "entertaining"; its lofty manner, philosophical yet rhetorical, is not softened, unless the addition of a bit of moralizing here and there be taken as a sugar coating to a rather thorough course in elementary science. Higgins also wrote "The Philosophy of Sound and Musical Composition" (1838), "The

Earth," and other examples of exactly the same sort of popularized science.

To do just that very kind of work, Henry Brougham, later Lord Chancellor, began about 1826 to organize the Society for the Diffusion of Useful Knowledge. With Charles Knight—whose earlier enterprise of a "National Library" had failed—Brougham soon began to issue cheap books on scientific and educational subjects. The first was his own "Discourse on the Objects, Advantages, and Pleasures of Science," [8] and this was followed by "The British Almanac," which, unlike most almanacs of the time, gave intelligent information rather than superstitious lore. The astronomical portions were supervised by John William Lubbock, banker and astronomer, the father of Sir John Lubbock, who wrote many works of popular science and endeared himself yet more to the British public by inventing "bank holidays." A "Library of Entertaining Knowledge" was inaugurated in 1829; its books appeared in monthly half-volumes like magazines. To this set Charles Knight contributed a book on "Menageries."

One principal object of the society was to inspire and encourage ordinary folk to engage in study and in original investigation. Accordingly, there had to be biographies of the "Men Who Rose" sort. Thus George Lillie Craik wrote a volume on "The Pursuit of Knowledge under Difficulties," and even after the society disbanded, Samuel Smiles continued to write biographies of engineers and discoverers.

In 1831 Knight established the *Quarterly Journal of Education,* and in the following year the *Penny Magazine,* and soon after that the "Penny Cyclopedia," whose eight volumes were sold in the form of weekly instalments at one penny each. In 1844 this huge enterprise was completed at a loss of £30,000 to the society, which went out of existence two years later. Professor George

[8] See Chapter IV, above.

Long, Thomas Hewitt Key, and Augustus de Morgan, of the newly founded London University, were among the writers for the society, as was also Sir Henry T. de la Beche. Robert Chambers, the Edinburgh publisher whose notorious "Vestiges of Creation" attained the dignity of public scandal, single-handed did a popularization work fit to be compared with that of the society.

Among the most competent of the diffusers of useful knowledge was Sir David Brewster.* Editor for years of a cyclopedia to which Carlyle among others contributed, co-worker with Henry Brougham in founding the Society for the Diffusion of Useful Knowledge, winner of the Royal Society's Copley medal, and one of the founders of the British Association, he united in himself the scientific soundness and the gifts of popular appeal that made him an able exponent and representative of science. His invention of the kaleidoscope—an ingenious instrument for the production of symmetrical patterns—won him quick riches, while his deeper explorations into Optics and especially into the polarization of light brought the respect of colleagues and eventually a knighthood.

His writings have an aristocratic quality, a chaste yet shapely art used with evident intent and successfully appealing. Besides his "Treatise on Optics" (1831) and his "Memoir of Sir Isaac Newton" (1855), his more intentionally popular works are "Heat" (1829) which is a small but thorough volume, "Martyrs of Science" (1841), originally a Presidential Address that briefly and stirringly recounts some phases of the history of science, "Letters on Natural Magic" (1851), a general outline of the sciences of vision and hearing conceived most sensationally, and "The Kaleidoscope, Its History, Theory and Construction with its Application to the Fine and Useful Arts" (2d edition,1858) in which a difficult subject is wrestled with and worried into at least reasonable clarity.

* (1781-1868.)

Charles Kingsley,* better known today for his novels than for scientific writings or for his active participation in church politics and polemics, was an amateur geologist of considerable ability. He conducted several series of popular scientific lectures with a success that may have been due partly to his own lack of professionalism in science. In 1885 these were collected as "Scientific Lectures and Essays." In all of these the author's touching faith in the rightness of everything, in the inevitable ultimate triumph of truth and knowledge, in the intelligence of the ordinary man, rouses him both to write with loving artistry and to express his deepest emotions. He hopes for the day "when ignorance of the primary laws and facts of science will be looked on as a defect, only second to ignorance of the primary laws of religion and morality." He sees no inconsistency between religion and science nor any objection to a clergyman giving scientific lectures, since "to those who believe in God . . . the grain of dust is a thought of God." Indeed often enough, though with moderation and good taste, Kingsley uses a scientific hypothesis to point a moral or to embellish a doctrine. Yet it must not be supposed that he is unscientific; Kingsley knew much, especially of geology. He boldly accepted the ideas of Lyell, still more boldly and confidently those of Darwin, for he could see no evil in anything true. His is perhaps the most skilled example of "writing down" to the level of the untrained mind that can be found. Doubtless his hearers felt, as not all listeners to scientific lectures can, that an enchanted land of strange knowledge was being opened to them and that they might walk there without fear of sin.

Kingsley knew also how to write science for children; he concealed his facts, theories, conclusions as skilfully as the inevitable moral so that many a child has devoured his books, never realizing until he reread the book in maturity that he was being subtly instructed and in-

* (1819-1875.)

spired. There is, for instance, "Glaucus; or, the Wonders of the Sea Shore" (1855), a juvenile geology text. Better known is "The Water Babies" (1863), a charming fairy-tale, full of satire on the foibles of savants, with many a whimsical implication of Darwinism lightly launched; there is "Madam How and Lady Why" or "First Lessons in Earth Lore for Children" (1869) which was reprinted fourteen times before 1911. He had the knack of building upon what his hearers surely knew to what he knew they would want to know. He respected their prejudices, coddled their human weaknesses, roused their manly ambition, did excellently as a popular writer. He was thus first and foremost a publicist whose sure instinct led him to use science as one of the best instruments for reaching the public. In this he is almost the exact antithesis of another very skilful popularizer of science, William Kingdon Clifford.*

Clifford was a brilliant mathematician, whose original studies in advanced physics and mathematics had attracted wide notice. But even more than his desire to penetrate the depths of the reason inherent in nature was his social wish to share his knowledge with others, especially with those who lacked the formal preparation for such learning. He was one of the most stimulating of instructors, popular lecturers, and writers. His career was brief and splendid. He first published a "Preliminary Sketch of Bi-quaternions" in 1873 and in 1877 another classic "On the Canonical Form and Dissection of a Riemann's Surface." In 1878 appeared his "Classification of Loci." In 1879 he died; his popular addresses were issued in collected, edited form posthumously. They are: "Elements of Dynamic" (1879-87), "Seeing and Thinking" (1879), "Lectures and Essays" (1879), "Mathematical Papers" (1882), "Common Sense of the Exact Sciences" (1885), the second, the third, and the last being the most notable.

* (1845-1879.)

It was Clifford's especial function to show how the most abstract, least human of the sciences can be expounded in touching imaginative style and with a minimum of technical routine terms. His "Common Sense," for example, is a treatment of arithmetic, algebra, geometry, physics, mechanics, calculus, all philosophically thought through and with no intellectual gaps. It is not easy reading, but is entirely free from technicality. All symbolic "shorthand" formulæ are clearly interpreted for the reader and illustrated before they are used; they develop an associative value, a literary flavor. Says the author, "We may always depend upon it that algebra, which cannot be translated into good English and sound common sense, is bad algebra." [4] And elsewhere [5] . . . "directly you begin to think that there is some hidden and mysterious meaning in it, which cannot be expressed in simple, ordinary words that everybody could understand, there is no end to the nonsense that it will help you to think and talk." He often pictured invisible things or even purely theoretical concepts in most vivid form, with a queer, unexpected twist to lend a fillip of novelty to the entire proceeding. Of Clifford, John Fiske declared: [6] "His skill in scientific exposition . . . for taking the most hopelessly complicated and abstruse subjects and making them seem perfectly simple and almost self-evident to ordinary minds, I do not know who could be found to compare with him. . . . Such scientific exposition . . . is as beautiful as poetry. In reading it one feels how the glory and beauty of Nature are immeasurably enhanced for the philosopher who can thus by inward vision distinctly grasp objects and relations too subtle for the eye of sense in any wise to discern."

An even greater writer, even more successful popular

[4] "Common Sense," p. 21.
[5] "Of Boundaries" (in "Seeing and Thinking").
[6] "Excursions of an Evolutionist," p. 323.

scientific lecturer, was John Tyndall,* later incumbent of Faraday's chair in the Royal Institution. Descendant of the William Tyndale who tried to translate the Bible into English and who, for his religious independence, was burned at the stake in 1536, this Victorian protestant expressed the same fierce adherence to what he considered the truth as did his ancestor. The field of battle had shifted, however; instead of fighting for the right to know the Bible, Tyndall fought for the right to criticize Scripture, earning the tribute of a plural reputation; that is, preachers would speak bitterly of "the Huxleys and the Tyndalls," those proponents of materialism. For he viewed nature frankly as a material existence—and lived with an idealist's emphasis upon such ethical concepts as honor.

He does not even approach Faraday, for example, in original discovery, but he far surpasses that physicist—and almost all other scientific writers—in the stirring and beautiful prose in which his lectures were couched. "He stands almost alone in the poetic vividness, force, and finish of his style" in "bold and striking pictorial imagery," said [7] a contemporary, and in the "coloring of reality. . . . No man better understands the high office of imagination in science. . . . Of ardent and poetic temperament, and at home among the grandeurs of natural phenomena, there is often an inspiration in his words that rouses and thrills our highest feelings. . . . Clearness, force, vividness of description, felicity of illustration, and the eloquence inspired by grand conceptions, are the striking features of his style."

Strangely, he dealt with what most persons regard as opposites—ice and fire. An ardent Alpinist, who sought the crags for diversion as well as for study, he early produced volumes on "The Glaciers of the Alps" (1860) and

[7] Introduction to his "Advancement of Science," Amer. ed.

* (1820-1893.)

"Forms of Water" (1872), in which the action of bodies of ice is studied. His most famous work is a very thorough though popular treatise on "Heat as a Mode of Motion" (1863). This was originally a course of eighteen lectures, delivered before actual audiences, and naturally is very circumstantial in its accounts of hundreds of experiments which, the reader must suppose, were being performed by the speaker before the eyes of the observers. With elaborate simplicity, with unmistakably visual clarity, each piece of apparatus is described, each experimental step narrated. Thus the history of discovery in the field of heat is set forth; thus various aspects of the theory, heavily documented with masses of systematically yet interestingly presented fact, are unfolded. The author has an eye for the sensational, as when he cites "freezing a liquid in a red-hot vessel." He never forgets the human implications of even the most inanimate matter and its behavior. In discussing the sun's activity, Tyndall *must* show how its radiant energy is the basic condition of life and thought and spirit. A little humor, a little playful irony crops up now and again to relieve even the pleasant tension of his usually earnest discourse.

Nor were these powers the gifts entirely of an unconscious "speaking from the heart." That Tyndall had definitely given thought to his problem of how to penetrate the minds of his hearers is evidenced by numerous remarks in his writings. One volume contains "Essays on the Use and Limit of the Imagination in Science" (1870). Here, in two reprinted addresses and an essay, literary questions are met most ably. Like Huxley, he insists upon the use of "language which shall leave no mistake as to his meaning," for, he declares,[8] I take it to be well worth the while of the scientific teacher to take some pains, and even great pains, to make those whom he addresses copartners of his thoughts." He knows also

[8] "Scientific Use of the Imagination," p. 129.

JOHN TYNDALL

how to make them emotional copartners—sympathetic, rather than bored or hostile, listeners, even enthusiastic followers. Second only to his inveterate habit of plain speaking in simple words is the courage which inspired so much of his writing. "You see," he could remark with obvious truth, in the midst of a lecture, "I am not mincing matters." He was frankly materialistic; frankly he defied those who publicly warned him "that as a result of [his] impiety, the bolts of heaven were in a state of potential suspension above [his] head, ready to descend if further drawn upon."

Third in importance is his unusual understanding of imagination—a power too often lacking, or disciplined into atrophy, in men of science. He held imagination to be "the mightiest instrument of the physical discoverer," when "bounded and conditioned by co-operant Reason. . . . In fact, without this power, our knowledge of Nature would be a mere tabulation of coexistences and sequences. We should still believe in the succession of day and night, of summer and winter; but the soul of Force would be dislodged from out universe; causal relations would disappear, and with them that science which is now binding the parts of Nature to an organic whole."

Besides this faith in the imagination of the discoverer, Tyndall understood how to manipulate imagination as a tool of the writer. Rarely does he state a general principle without instantly illustrating it with a cloud of specific, vividly pictured, bright little special cases. "The chick," says he, "might be deduced as rigorously from the egg as the existence of Neptune was deduced from the disturbances of Uranus." He contrasts the pyramids of Egypt with the crystals that form in a salt solution, compares the animal body with the stalk or the ear of corn, cites "Newton's passage from a falling apple to a falling moon," and so on without end. His playing upon the keyboard of imagination, furthermore, transcends the

merely useful. He does not stop with showing a clear picture, but goes on to paint, in apt colors of language, majestic scenes, to unroll panoramas that thrill and exalt the spirit, that stir up the noblest of emotions, that relieve the burden of existence and release the mind from its prison-house of the commonplace as perfectly as is done by the purest of poetry.

For one thing, Tyndall wrote with an essential and inevitable concern for the human significance of his subject. His illustrations show this; even more decisively is it shown by the entire frame and composition of each essay, by the conclusions and applications of his thought. Like his great ancestor, he was always at least part moralist, and a moralist—unless he be of the soured variety—must be concerned about people, their problems, their duties, their fates. Like Huxley he was fighting for the liberation of thought, but unlike that great gladiator, Tyndall treated the opponent with courtesy and something of respect.

Furthermore, he had a decided fund of humor, as keen as Huxley's irony but kinder, mellower, and somewhat more frequent. Irish by birth, he gloried in a fight, enjoyed it, laughed through it, saw no bitterness in conflict. He was an optimist, too, proud of the advances his era had made and hopeful of more. These traits are exemplified in his remark that "the process of things on this earth has been one of amelioration. It is a long way from the Iguanodon and his contemporaries to the President and Members of the British Association." [9]

His many essays and speeches have been collected more than once so that his various books partly overlap one another. Besides those already named, he was the author also of "Light and Electricity" (1871), a compact but complete little treatise designed along the same lines as the volume of heat, "The Advancement of Science,"

[9] "Scientific Limit of the Imagination," p. 64.

originally delivered as the Presidential Address before the British Association at its Belfast meeting in 1874, and "Fragments of Science for Unscientific People" (1871), "a series of detached essays, lectures, and reviews," including "The Constitution of Nature," a brief but thorough outline of physics, which, together with Huxley's "Physical Basis of Life," led to a considerable controversy.

Unlike Tyndall, John Lubbock* was a man who did not need nor want to fight, though his later adherence to the theories of Darwin—his country neighbor and lifelong friend—might have led to much combat. On the whole, the world was kind to this banker's son,[10] who passed through Eton and his father's counting-house to Parliament and a baronetcy, taking in science rather casually as he went yet managing to enrich it by some original studies and to interpret it in frequent series of saccharine essays for the nice ladies and gentlemen who thought the new discoveries quite charming. He attained real distinction in several fields—anthropology, entomology (the study of insects), botany, and geology—as well as considerable skill in writing the purely literary essay. A list of titles will sufficiently indicate this; it includes: "Prehistoric Times" (1865) which led to a reproachful rejoinder from the Duke of Argyll, "The Origin of Civilization" (1870), another interesting study of the early conditions of mankind, "The Origin and Metamorphoses of Insects" (1873), "British Wild Flowers" (1875), "Ants, Bees and Wasps" (1882), one of his most original and

*Later Lord Avebury (1834-1913).

[10] Even his flair for scientific writing was inherited. His father, Sir John W. Lubbock, was one of the group that helped to maintain the Society for the Diffusion of Useful Knowledge and had himself written a treatise entitled "Remarks on the Classification of the Different Branches of Human Knowledge," published by Charles Knight, the second edition appearing in 1839. His mathematical treatise "On Probability" (1830) and his astronomical "The Stars in Six Maps" were likewise sponsored by the Society. He also wrote "An Elementary Treatise on the Tides."

detailed books, yet not unpopular, "Flowers, Fruit, and Leaves" (1886), "The Pleasures of Life" (1887), "The Senses, Instincts, and Intelligence of Animals" (1888), "The Beauties of Nature and the Wonders of the World We Live In" (1892), an intensely yet graciously popularized first primer outline of natural science, and "The Scenery of England" (1902). The author, always a perfect English gentleman, here reveals himself as a congenital patriot to whom love of his own land is inevitable. There is a constant undercurrent of gentle moralizing, a plea to appreciate the world, that "fairyland of exquisite beauty." Yet despite its sentimentality, the volume—like all of Lubbock's—does convey much real information in compact and simple and pleasant form. It is interesting to find his literary creed stated in these words: [11] "Technical works, descriptions of species and so forth, bear the same relation to science that dictionaries do to literature." It was never his aim to be a compiler of scientific dictionaries, but rather a guide for the uninitiated into the strange land of nature and its laws.

Even further from the technical in spirit—too far, perhaps—is Arabella B. Buckley's little book, "The Fairyland of Science." Miss Buckley had been secretary to Sir Charles Lyell and had accordingly imbibed much geological knowledge which she here redistributed in ten lectures with no "pretensions to originality, their object being merely to explain well-known facts in simple and pleasant language" for children. But she goes to the length of calling simple phenomena, such as freezing, "enchantments" and lays down emotional laws, such as that "we must have imagination" and that "it is necessary to love knowledge and make it lovely."

Quite on a different plane is the work of the two Geikie brothers,* Scottish geologists of high standing. Both of

[11] From the essay on "Science" in "The Pleasures of Life."

* Sir Archibald Geikie (1835-1924), Professor James Geikie (1839-1915).

them were professors, both made real and significant original studies, and both wrote often for their colleagues as well as sometimes for the general reader. Yet each had a strain of pure poetry in his soul, a strain that came to the surface even in the works not intended to be sugar-coated. Both studied glacial phenomena, and James succeeded his elder brother as Murchison Professor of Geology in the University of Edinburgh. Both were past masters of the art of exposition, unashamed to pour forth image-bearing words in beautiful patterns. Of the two James Geikie had perhaps the more graceful style.

Sir Archibald Geikie's principal works are these: "The Story of a Boulder: or, Gleanings for the Note-book of a Geologist" (1858), a rambling but informative discourse, "A Geological Map of Scotland," prepared in collaboration with Sir Roderick Impey Murchison, veteran geologist, "On the Phenomena of the Glacial Drift" (1863), another but more popular first study, and "The Ancient Volcanoes of Great Britain" (1897). This tremendous work, skilfully written, sums up the whole body of knowledge that had been gradually gathered on the subject. The author also wrote text-books and delivered innumerable lectures, papers, presidential addresses that have been collected and reissued. An excursion into a somewhat different field is his "Types of Scenery and their Influence on Literature" (1898).

James Geikie's monumental work is "The Great Ice Age and Its Relation to the Antiquity of Man" (1874). In this neatly devised book, with its graded advance from the known to the unknown, Lyell's hypothesis of uniformity is maintained and applied to new cases. In the next book, "Prehistoric Europe" (1881), reasons are given for a belief that there have been at least five interglacial periods. "Fragments of Earth-Lore: Sketches and Addresses, Geological and Geographical" followed in 1893,

"Earth Sculpture" in 1898. A verse translation of the lyrics of Heine and other German poets showed another side of the versatile geologist's mind.

A contemporary and colleague of theirs was Professor T. G. Bonney,* whose "Volcanoes—their Structure and Significance" (1899) is much quoted. The book was deliberately planned to provide "a whet for the appetite of the ordinary reader." Accordingly it avoids the usual mass of confusing introductory definitions, often repeats statements for the reader's convenience, works new terms into the flow of discussion and thus into the reader's consciousness gradually. The manner is easy and gentle, descriptions are vivid, sometimes even sentimental, and there are accounts (of eruptions) that cannot be distinguished from similar narrations in a Victorian novel.[12]

Sir Robert Stawell Ball (1840-1913) did much to make astronomy generally understood. His works—"The Earth's Beginning" (1901), "The Story of the Heavens" (1885) and so on—are dignified, scholarly, clear, richly informative, and as simple as the subject matter permits. E. Ray Lankester (1847—) who occupied Sir Richard Owen's office as Director of the Natural History Departments of the British Museum, was a skilled and energetic popularizer. Typical works are his "Extinct Animals" (1906), which is nothing "more ambitious than an attempt to excite in young people an interest in a most fascinating study," yet is substantial as well as sensational, and his "Science from an Easy Chair," a set of disconnected essays written mostly in 1910.

This brings the story well out of the Victorian period into our own day of intensive, almost feverish popularizing. There are many gifted writers at work now turning the dry bones of formal learning into food for the mind

* (1833-1923.)

[12] Others, "The Story of Our Planet" (1893) and "Ice Work Past and Present" (1896) are equally well done.

and spirit of all men. A better name than popularizing has been devised of late for this process; now it is called humanizing of knowledge, and with the new name it seems likely to attain to a new dignity. In the natural history field, the long list of Professor John Arthur Thomson's books holds an honorable place, both for material and for art in the presentation, works unashamedly for every man and fit for a place in the world of literature as well as in the world of science.

CHAPTER XXII

NATURAL HISTORY ESSAYS AND JOURNALS OF TRAVEL

There is a whole literature lying somewhere on the border between what is intentionally scientific and what is by intent purely literary. Until the recent emergence of the machine age, it was a commonplace observation that poets and men of letters were all deeply interested in nature. They used nature as a background, to lend a fuller richness to the human story which was being unrolled. Many have had but hazy notions of what nature is, vague impressionistic compositions of masses of waving leaves and tossing oceans, sufficient for a background. Others have been more circumstantial, tracing the seasons and their manifestations in some locality. An interesting essay by John Burroughs analyzes the writings of several of the foremost authors in English literature and shows how many of them are guilty of little lapses in their description of nature. One describes a garden, naming several species of flowers in bloom which could not possibly be blossoming at the same season. Another mentions the song of a kind of bird which never does anything more artistic than chirping, and so on. Yet, despite such blunders, it is safe to say that most men of letters are deeply interested in nature.

Some writers have a more than ordinary fund of exact or definite knowledge of the facts of nature, based upon genuine observation, yet not so organized and coördinated as to constitute a regular scientific system. They write accounts of what they have noted, accounts full

of correct detail, quite free from scientific method or terminology, incapable of being studied for the purpose of learning. Their motive is not that of the more usual scientific writer, for they do not mean primarily to expound a subject but rather to express a spiritual experience. Nor are such naturalists to be considered popularizers, since, unlike Tyndall and Huxley, they do not aim to give a difficult matter an easy presentation so that untrained readers can grasp it. Their motives are, rather, exactly the same as the motives of any literary essayist—to convey æsthetic pleasure and win æsthetic appreciation. The fact that these essayists use material taken from natural history does not at all remove their work from the field of belles lettres. Essays of this kind are, in fact, widely read, often by persons who are not conscious of possessing scientific interests. They are criticized according to the standards of literary criticism, by lay reviewers who would not presume to judge technical works. In short, natural-history essays are generally admitted to belong to literature. Therein they differ from many of the works reviewed in this book, whose right to be considered part of literature is advanced here for the first time.

A great many natural-history essays have much in common, due, perhaps, not so much to the requirements of the subject as to the temperaments of the writers. It is common for such essays to have no definite structure or some purely casual plan, the outcome of a free, rambling association of ideas. An example of this trait is W. H. Hudson's last work, "A Hind in Richmond Park," which might be regarded as a treatise on the senses. It begins with a personal anecdote about a deer which directed one ear forward to listen for the numerous sounds coming from the wood and the other ear backward to listen for a hunter's whistle. Other senses come to take the floor, not exactly helter-skelter, for that would imply

with panic speed, but with apparent aimless wandering. Much of the book deals with smell, but there are discussions of sound and music and of such scarcely demonstrable senses as the sense of direction, telepathy, spectra, or visions seen in the wind, a sense of "polarity" or "north-and-south-ness," and so on. It is richly personal and shows marks of the author's violent opinions. Casual instances lead to general theorizing, and in this it is not scientific; but Hudson is an exact observer, if an unsystematic thinker, and he draws his material from the field of natural knowledge, so that it may fairly be considered scientific writing. Above all, it illustrates richly the casual order in the presentation of its substance.

A similar casualness in presentation marks much of the work of Burroughs, Fabre, Jefferies, Thoreau, and other of the best natural-history essayists—so much so, and so significantly, that this group of writers might be called "casualists." This term would include books, other than essays, composed in the same spirit.

Most writings of this sort are dominated by outdoor observation, often minutely detailed. Such individual facts, which frequently are fascinating in themselves, rarely have much connection. As a rule there is little attempt at constructing theories, though the essayist may go the length of asserting a general belief illustrated by one or more observed facts. For instance, in Burroughs' essay, "The Wit of a Duck," [1] the general theory that animals remember and apply what they have seen is based upon the story of a duck that found its way home over strange roads. A great part of such essays is inevitably given over to descriptions, exact and reliable enough, but quite literary in their emotional and pictorial quality and their freedom from mere measurements.

Again there is likely to be a large element of personal narrative. The natural-history essayist tells how he saw

[1] From "Ways of Nature," 1905.

this or heard that on a certain wintry morning, how a particular bird or tree of his acquaintance behaved under special circumstances. He even may interlard his talk of flowers with something entirely personal, a boyhood reminiscence or curious old legend which is relevant more because it happens to be interesting than because the unfolding of the subject demands it.

Some essayists ramble off into elaborate philosophical reveries about human life, duty, the soul, and the hereafter, or about ancient times when the land they are inspecting was the scene of romantic episodes in history. In this they are truthfully recapturing the mood of one who wanders about the fields or woods, noting a woodchuck, when one appears, or a strangely formed cloud or rock, looking for leaf-buds or arrow-heads, meditating also as one strolls along. If a keen modern novelist were to depict a real scientist's "stream of consciousness" during a field expedition, the outcome might essentially resemble this type of essay.

It is natural, too, that such essays as these deal rather with plants, the more interesting insects such as bees, and domestic animals or the more accessible or the more romantic of wild animals. Birds are in particular favor with natural-history essayists—which is to be expected, since birds have an especial appeal (due to their familiarity yet invincible remoteness, their æsthetic charm, and their super-mundane powers), to the imagination. Careful classification of species has no place in these writings; microscopic plants and animals are scarcely ever mentioned, nor are fossils and the other dry bones and ashes of science. Chemical and physical studies do not seem to find their way in at all.

Just who it was that began to write of nature seriously yet casually must remain unsettled. Many scientific authors of the Middle Ages seemed to recognize no difference at all between writing of knights and ogres and

writing of medical treatments and the philosopher's stone. A convenient starting point is found in Robert Burton's * classic treatise, "The Anatomy of Melancholy, What it is With all the Kindes, Cures, Symptomes, Prognostickes, and severall Cures of it, in Three Maine Portions, with their severall Sections, Members and Subsections, Philosophically, Medicinally, Historically opened and cut up . . . with a Satyricall Preface, conducing to the following Discourse" (1621). It is a strange book indeed, as strange as its title, a curious investigation into that no less curious Anglo-Saxon neurosis. Strange lore is heaped in pell-mell with erudite citations from ancient Greek, Roman, biblical, and early Christian authorities; eleven adjectives are piled one upon another where two would be sufficient and three too many—and this with an effect of exuberance most winning. A picture of life in Jacobean England, a depiction of humanity at every time and in every place, this basically medical treatise has been a favorite among intelligent men in all ages. "Milton read it, deriving hints for 'Il Penseroso,' Sterne pillaged it; Lamb admired it and imitated its quaint style. . . . Dr. Johnson said that it was the only book that ever took him out of bed two hours sooner than he wished to rise." [2]

In the same great seventeenth century came the most famous work of casual natural history, Isaak Walton's † "The Compleat Angler; or, Contemplative Man's Recreation" (1653). This book, partly in narrative, partly in disjointed essays, partly in loosely connected essays, partly in dialogue, always in kindly, quiet, whimsical discourse, manages to explain a great deal about fish, fishing, and men who fish for sport. It sets up those ideals of sportsmanship which mark the angling recreation to this day. Through the magic of Walton's gentle enthusiasm, fishing has ever since been invested in a charmed haze of imperial purple. Perhaps it is because of his writing

* (1577-1640.)
† (1593-1683.)

[2] International Encyclopedia.

that Presidents of the United States have themselves photographed booted to the hips and wielding rod and tackle.

More than a century after the "Angler" there appeared a modest volume of letters written by a parish clergyman * to two county gentlemen who, like himself, were interested in nature. That book, "The Natural History of Selborne" (1788), is a splendid instance of what scientific and literary use can be made of a restricted field. White travelled little, had almost no intellectual company, and must have had but little access to books of science. He was an amateur at the weightier parts of science and accordingly trusted much to his own observation and local rumor, but was honest enough to say so. He knew and loved the locality, its hummocks and dingles, its plants and its birds, and seems never to have thought of not making his work personal. Though much is narrated in the first person, it is accurate. Vivid, detailed descriptions alternate with "queries" which the writer propounded without (apparently) going out actively to seek answers. The illustrations he uses are all homely and as sound and clear as apples. Often one meets with observations placed directly in their settings. Now and again a significant original discovery is made; for example, White discovered the anatomical fact that deer have two extra breathing vents. The whole volume —originally, be it recalled, a group of separate letters— reads like a notebook, so full is it of disconnected though fascinating jottings. The items are of the quaintest; a sort of local wise-woman known as a "cancer-doctress," an ingenious "musical friend" who "has tried all the owls that are his near neighbors with a pitch-pipe set at concert pitch, and finds they all hoot in B flat," his own projects for better church-spires, jackdaw-breeding, and "an elegant landscape." His work provided the best example of his own saying that "all nature is so full that

* The Rev. Gilbert White of Selborne, (1720-1793).

that district produces the greatest variety which is the most examined." It is not surprising that Darwin acknowledges White's "Selborne" to have been an important boyhood influence in directing his mind toward a study of birds. "In my simplicity," he remarks, "I remember wondering why every gentleman did not become an ornithologist."

White, like Walton, is a large figure in literature. It is not equally well known that Thomas Gray, author of the "Elegy Written in a Country Churchyard," was an eager and consistent naturalist. After the age of forty, he wrote no more poetry and did as little of the work of his Cambridge lecturership as possible. Much of his solitary life was spent in exploring the countryside, armed with Linnæus' "Systema Naturæ" and Hudson's "Flora Anglica." He had his copy of the latter book interleaved and annotated it strenuously. He drew accurate, sensitive sketches of birds and plants and wrote detailed accounts of his observations—in Latin, Italian, and French, as well as in English. "He was an accomplished botanist [3] and his notes are excellent in their succinct statement of distinctive characteristics and in the variety of information conveyed in them. They are, almost without exception, confined to fact, but now and then there is a sentence in them which reveals the poet." These private notebooks, kept only as a hobby, were not published during Gray's lifetime.*

The earliest writer of this group who may be called Victorian is Charles Waterton, surnamed "the Wanderer." † His only book, which like "Piers Plowman," was revised and re-issued again and again, recounts the author's "Wanderings in South America, the Northwest of the United States, and the Antilles, in the years 1812, 1816, 1820, and 1824." The first edition appeared in 1825, and

[3] From "The Poet Gray as a Naturalist," by Charles Eliot Norton, p. 15. * (1716-1771.) † (1782-1862.)

thereafter the eccentric John Bull of a Catholic country squire ceased wandering, to spend his long decline in improving an inherited estate, breeding birds, and revising his book.

Properly it is a naturalist's journal of travel, though it must be understood that Waterton knew little of systematic science and had a "rooted abhorrence of scientific names." He travelled in Demerara and along Lake Parima, intensely interested in the matted Brazilian jungles and their dwellers, both animal and human. Whatever caught his notice was described in the quaint, pretentious language of a gentleman hunter who has not quite forgotten his Virgil and means to bludgeon his unpractised pen into a solemnity in keeping with the greatness of the subject. Inevitably a great portion is stirring personal narrative, full of the adventure and lustyhood of a more natural age, which not all the "thous" nor Latin quotations can blur. His barehanded fight with a cayman—monstrous alligator—*in the water,* his experiments with Wourali poison brewed in the dead of the moon under terrific spells, his accounts of the fiendish little chigoes that make nests in bare human feet—these and a host of other items grip the least studious of readers. At times there are emergences of a sense of humor. Descriptions are both colorful and accurate. The transitions are feeble, the style rambling, almost structureless. Self-conscious as Waterton must have been, he writes both elaborately and with carelessness unexpected in an author. Withal there is much genuine and detailed record of observation incidentally embedded among the breccia of his narrative. He had greatly advanced the art of stuffing dead birds for display in museums, and the directions for practising that art are here given. He was the first to study the sloth in its native environment; accordingly his accounts of the maligned beast are significant. Frankness marks Waterton's writ-

ing, for, despite his striving for effect, sportsmanship kept him to the truth. William Beebe and Theodore Roosevelt have praised him for his power of stimulating a passion for nature.

Innumerable English naturalists have travelled in far places, often in order to collect specimens or study wild life, and have supplemented their technical publications with a narrative of travels, aimed at the general reader yet richly stocked with information. Charles Darwin produced his "Journal of Researches" after the famous voyage of the *Beagle,* Alfred Russel Wallace gave the world his "Travels on the Amazon and Rio Negro," and Henry Walter Bates his "Naturalist on the River Amazons." We have discussed these books as well as Humboldt's "Personal Narrative" of travels, so that nothing more need be said of them here. In 1819 William Cobbett published "A Year's Residence in the United States of America," which included chapters on natural history and agriculture. Something of the same sort was Hugh Miller's "First Impressions of England and its People" (1847) which treated of geology as well as of humanity. In the same year Sir James Ross, with Joseph D. Hooker's aid, produced the "Voyage of Discovery in the Southern Regions," which, however, was far more systematic than any other travel book here mentioned. Paul du Chaillu, the champion hunter of history since Nimrod, wrote what has become a juvenile classic in his "Explorations and Adventures in Equatorial Africa" (1861). Sir S. Baker carried this theme to the unknown lakes in the interior in his "The Albert Nyanza" (1866), and "The Nile Tributaries of Abyssinia" (1867), as did Sir Henry Morton Stanley in his more famed "Through The Dark Continent" (1878) and "In Darkest Africa" (1890). H. O. Forbes told of observations in the Eastern Archipelago in his "A Naturalist's Wanderings" (1885). And there were still more.

But "the best of all natural-history journals which have ever been published"—at least in Darwin's opinion [4]—was Thomas Belt's "The Naturalist in Nicaragua" (1874), "a narrative of a residence at the gold mines of Chontales, journeys in the savannahs and forests, with observations on animals and plants in reference to the theory of evolution of living forms." This book is indeed especially interesting and especially valuable. The author, employed at a gold mine because of geological knowledge, supplies much material concerning earth-forms. His intense interest in both botany and zoölogy makes his accounts of tropical life substantial, meaty, while the zeal he felt for the evolutionary hypothesis lends a direction to his thoughts that partly overweighs the usual haphazard character of travel diaries. "It is full of theories," says the author,[5] "I trust not unsupported by facts. . . . The thoughts are those of a lifetime compressed into this little book; and like the genii of the Arabian tale, imprisoned in an urn, they may, when it is opened, grow and magnify, or, on the contrary, be kicked back into the sea of oblivion."

Belt,* who admitted knowing no language but his mother-tongue, knew that one well and could command all its resources for producing the effects he wished. His long, organ-like sentences roll majestically, musically; the phrasing is apt and the imagery both rich and suggestive. Whether expounding geological facts, biological theories, giving pictures of social and political life, or narrating his own adventures, he almost always manages to grip the attention and please the taste. His descriptions are vivid as well as exact. Every experiment and every observation is described so objectively that a reader can both visualize the situation and trust the account of it. Every conclusion is supported by reasons, which the reader is tacitly invited to weigh and judge.

[4] See "Life and Letters," II, p. 366. [5] Preface. * (1832-1878.)

Technical language is used, but only sparingly and generally with hints or explanations of its meaning.

There are some high spots, memorable for their intensity of beauty or interest, such as the picture of a tropical forest after a storm and the truly epic account of a mobilization of "army ants" that terrorize the small creatures of the underbrush. In all, Belt's is a book to be remembered—after it has been enjoyed and pondered.

A minor essayist was Francis A. Knight, whose book of gentle essays, "By Leafy Ways" ("Brief Studies in the Book of Nature") came from the press in 1889. Though the language is figurative and artfully stylized, its main purpose is instructional, and it seems to give reliable information. The atmosphere is pleasant and cheery. Impersonal in actual substance, the book conveys a sense of personality.

During the last quarter of the century London became aware of a natural-history essayist of positive and genuine, if brittle, genius—Richard Jefferies.* In his Wiltshire village home, he had been known since early youth for strange, silent, swift ways, a sort of Shelley without the advantages of social self-confidence and literary training. He read much, though it is doubtful if any writer of natural history influenced him; indeed, he never heard of White's "Selborne" until late in life and knew nothing of either Thoreau or Burroughs. His most characteristic habit was solitary rambling and meditation. Largely by his own efforts he picked up a store of natural knowledge. His uncompromising intellectual honesty, rare powers of observation, and almost primitive patience led to his really knowing much, despite complete dependence on his own efforts for all learning. "As a matter of fact, Jefferies was not a scientific naturalist at all, if we use the term *scientific* in its limited technical meaning";* he was "a naturalist in a wider sense, a student of the

* (1848-1887.) * From H. S. Salt "Richard Jefferies—a Study," 1894.

natural in all its forms and phases, from the nature that is called inanimate to the nature that is called human." Like Darwin, he began with an interest in sport, especially hunting and snaring; he learned many things from an old gamekeeper, and even did "some profitable poaching for himself." In time he came to despise wanton or greedy poaching and developed a love of wild—that is, natural—life in all its forms. Eventually he evolved a sort of Rousseauistic philosophy of life. "Return," he would cry in almost prophet-like accents, "return! Back to nature and the simple life!"

One of the chief items in his literary creed was this: "Be very careful not to go too far; keep round the skirts of home, near the garden, or in the nearest field, else you will jump over the very best." Accordingly his descriptions are almost entirely of the south of England, the taste and "feel" of which permeate every paragraph. His earliest volume, "The Gamekeeper at Home" (1878), by the harmless pretence of studying the character of one who comes as near to being natural man as can be found in England, actually depicts the host of details which together make up a countryside. There are splendid scenic descriptions, full of the flavor of woods; and intimate love and knowledge of traditional, settled, yet colorful ways of life; and the style is both pure and stirring. The following brief portrait of the gamekeeper sums up much of Jefferies' philosophy and is a fair sample of his literary habit: "He is an ash-tree man, . . . hard, tough, unconquerable, by wind or weather, yielding but by slow and imperceptible degrees to the work of time. His neck has become the color of mahogany; sun and tempest have left their indelible marks upon his face; and he speaks from the depths of his broad chest, as men do who talk much in the open air. . . . In brief, freedom and constant contact with nature have made him every inch a man." With equal keenness the author characterizes

that "bold and desperate animal," the fox, or the rabbit, which "stops dead, as if petrified with astonishment" upon suddenly seeing a man.

In much the same vein is Jefferies' "The Amateur Poacher" (1879). Other of his volumes show even less pretence of design; the most typical are mere loose conglomerations of separate essays. Among them are the unforgettable little masterpiece, "The Open Air," which comes as near to bringing real farmland into the library as any book in English, his "Nature Near London" (1883), an outcome of his single, unsatisfactory attempt to live in or near the city, "Life of the Fields" (1884) which includes his famous "Pageant of Summer," "Hours of Spring and Wild Flowers," a pair of sentimental essays that try to present nature through the eyes of a hypothetical aged, dreamy peasant, "An English Village," which blends some antiquarian lore with geology and the more usual field natural history, and "Round About a Great Estate," a feeble narrative in a rich and racy setting.

In 1881 he published "Wood Magic," and from that time on a deeper note was apparent in Jefferies' work. His sincere adoration of nature was being warped into a systematic mysticism, which is neither convincing nor consistent with his temperament. He attempted fiction also, as well as disguised autobiography, but with indifferent success. Hugh Walker considers his "Bevis" (1882), in the same class with "Tom Sawyer," although "Bevis" totally lacks humor and has only the feeblest of plots. Besides that, it seems rather consciously *written down,* by a sophisticated adult, for boys, whom he scarcely understands. The aim is that old one, to combine pleasant reading with instruction in natural history. Its real virtue is, like that of all Jefferies' books, in its descriptions of nature. Little is gained by the narrative form into which they are cast, except that this enables him to

portray a type rather slighted in juvenile fiction—the dreamy, serious boy who is not ashamed to be good and to strive for the attainment of worthy ideals.

"The Story of my Heart" (1883) carries on more frankly his own account of his life. It is involved and awkwardly sentimental. Here, as Walker observes, "he seems to be perpetually straining after something which he cannot reach."

In "Amaryllis at the Fair" (1884), though the same inability to construct plot mars the story, its sincerity is maintained by a faithful, characteristic loyalty to minute and objective description. Further, there is one real character in this book: Iden, the philosopher-naturalist who has reverted to the peasant even in his speech. The community—when it did not exceed village scope—was fine material for Jefferies. He had keen penetration and stimulating ideas about rural sociology.

It is hard to read much of Jefferies at a sitting because of his inveterate habit of piling up detail, often interesting in itself and finely phrased, but delivered in unorganized, confusing multiplicity. "I shall leave analysis to those who like it, and go on recording facts" he proclaims,[7] and that is just what he did—to perfection and to distraction. "No English writer has ever possessed a more minute acquaintance with the facts of nature. But this, which is his strength, is also his weakness." [8] A little of Jefferies comes like a dewy breeze fresh from immemorial meadows; a great deal of him perplexes and wearies.

He has no message except that nature is good for the soul—nature and good old English ways, pure ale, and labor. The new industrial world, which he is scarcely aware of, frightens and irritates him. Says he: [9] "I do

[7] "Amaryllis," p. 33.
[8] Walker, "Literature of the Victorian Era," p. 1049.
[9] "Hours of Spring," p. 71.

not want change. I want the same old and loved things, the same wildflowers, the same trees and soft ash-green; the turtle-doves, the blackbirds, the coloured yellow-hammer sing, sing, singing so long as there is light to cast a shadow on the dial, for such is the measure of his song, and I want them in the same place. Let me find them morning after morning, the starry-white petals radiating, striving upward to their ideal. Let me see the idle shadows resting on the white dust; let me hear the humble-bees, and stay to look down on the rich dandelion disk . . . swifts shot through the air with outstretched wings like crescent-headed shaftless arrows darted from the clouds; the chaffinch with a feather in her bill; all the living staircase of the spring, step by step, upwards to the great gallery of summer—let me watch the same succession year by year."

W. H. Hudson,* who became famous only in old age, is scarcely known as a Victorian writer. Yet he had published eleven volumes, including some of his best natural-history essays, before Victoria died, and his immortal myth, "Green Mansions," came shortly after. Hudson had as passionate a love of the English soil as Jefferies, a love strangely thwarted and whetted through his having been born in the Pampas of La Plata and growing up to manhood in an unwilling exile. Yet his books show a fondness for the free, open-air, horseback-riding life of the South American plains, a respect for the manhood of the semi-savage gauchos, an instinctive harmony between his own spirit and the nature that so abundantly surrounded his youth. He was carefully educated and early began to collect facts as systematically as he could. He first appears in literature with a series of "Nine Letters on the Ornithology of Buenos Ayres" (1870),[10] in the course of which he took occasion to criticize Darwin's knowledge of South American birds.

* William Henry Hudson, (1841-1922). [10] See Chapter XVI, above.

As soon as he could manage it, he came "home" to England, where he lived a rather solitary, migratory existence, writing patiently about nature as he saw it in his fatherland and as he remembered seeing it in his native country. Success came slowly and late. Perhaps it was this that soured him; perhaps it was the effect of being kept away from home all through his youth; perhaps his unhappiness sprang from the constant drift of human society away from the nature and simplicity that Hudson loved, interpreted, and strove for. It is true that he was concerned over the future of society, that he saw nature as protagonist in a drama of which the human world is an important background, and that in many of his essays, he is preaching to men rather than depicting nature. His best known works, "The Purple Land that England Lost" (1885), "Green Mansions" (1904), are novels, and several others include a large element of fiction, narrative, and autobiography. No remarkable constructor of plots, no unusually able interpreter of character and motive, he none the less succeeded in the narrative genre far better than Jefferies, for Hudson did at least possess the power to show nature through the eyes of some person in the story; he could imbue the entire frame and substance of a story so impressively with the atmosphere of liana-hung forest, swamp, or downland, with the—accurately tuned—songs of birds and myriad rustlings of living beings, with the racy, chill scents of earth and air that the reader follows the adventures of the human hero among these things as tensely as if they were the commoner fortunes of career or love. "Green Mansions," the almost unearthly story of a girl in whom stirred the true, happy harmony of the spirit of nature, has taken so mighty a hold on public favor that monuments have been built to Rima, babies named after her, guest-camps are borrowing success by using the title of the book. Of the later story, "A Shepherd's Life" (1910), a reviewer

has said,[11] "there are few men with whom one may pass the time of day more delightfully than with Mr. Hudson."

Indeed, it is in this latter capacity, as talker, conversationalist, raconteur, that Hudson is most himself. In a little library of volumes made up of essays, with here and there a snatch of his life among the gauchos, or an episode from his explorations in England, or again some traditional, legendary yarn that has survived from an older world, Hudson talks. Yet despite his variety, a fundamental harmony underlies much of his writing: he has one love—nature; he has one doctrine—that man needs nature for the life of the spirit; he has one subject for scrutiny—the multiform details of the natural world which can be studied with patient, minute care, but dare not be dissected nor classified.

His chief volumes of essays are these: "The Naturalist in La Plata" (1892), "Birds in a Village" and "Idle Days in Patagonia" (both in 1893), fine, spirited sketches of his early days; "Birds in London" (1898), "Nature in Downland" (1900), "Birds and Man" (1901), "The Land's End" (1908), "South American Sketches" (1909), "Afoot in England" (1909), "Adventures among Birds" (1913), "Birds in Town and Village" (1919), "The Book of a Naturalist" (1919), and "A Hind in Richmond Park" (1922). His works of fiction, besides those already named, are "El Ombu" (1902), a group of short stories, "Hampshire Days" (1903), the fantasy, "A Little Boy Lost" (1905), "A Crystal Age" (1906), so-called novel which depicts a Utopian, utterly non-industrial existence in which almost sexless human beings live naturally, simply, "Fan: the Story of a Young Girl's Life" (1923) and "Dead Man's Plack and an Old Thorn" (1920), several historical stories. He was the author, too, of "Argentine Ornithology" (1888-9) with Dr. F. L. Sclater, and of "British Birds" (1895). While all his essays tend to

[11] *The Literary Review, N. Y. Evening Post,* Dec. 10, 1921.

become autobiographical at times, Hudson wrote certain volumes primarily as autobiography. These are: "Far Away and Long Ago: History of My Early Life" (1918), and "A Traveller in Little Things" (1921).

The reader of Hudson's books can form a good notion of the author's life and is left in no doubt as to his viewpoint. Hudson defines himself as "a naturalist in the old original sense of the word; one who is mainly concerned with the 'life and conversation of animals' and whose work is consequently more like play." What he wants is to recapture and preserve and share "a strange joy—an inherited memory and vision of a savage, prehistoric land of which we are truer natives than we can ever be of this smooth, sophisticated England." The study of nature can give man this joy, but it must not be the anatomizing, deadening sort of study. . . . "To kill your adder is to lose it. . . . We can read about the scales and bones in a thousand books. We want to know more about the living thing, even about its common life habits . . . the living things that were so much to me, my chief happiness having always been in observing their ways." . . . He is at one with "the flame of life in all its appearances." He can see from the viewpoint even of creatures that give most persons a shudder, such as wasps and snakes, not merely study them interestedly but actually picture the world, convincingly, as it must appear to one of them. Above all, however, he is at one with the birds, those swift, beautiful, graceful, airy beings that symbolize at once the ideal and the simply, physically natural. There is something birdlike in Hudson's personality, his migratory habits, his homing instinct, his quick, darting thoughts, his light, graceful phrases, his way of turning a subject over and letting his mind play brightly upon it, like the sunlight playing upon the shifting wings of a tanager. Though he is definitely a natural-history essayist, and love of birds is the badge of all that tribe, though

he was no mean ornithologist, neither of these seems to account for his peculiar and especial genius in displaying the bird-soul; it was somehow akin to his own. Accordingly he often sides with bird and beast in man's war against them. He never depicts with success a human character unless it be more than part bird, like Rima, or goat, like Caleb in "A Shepherd's Life." In a thoughtful sense, setting aside all idea of Dionysiac revelry, he incarnates the essence of Pan, for he lives and moves and has his being in the natural world, the world of humble creatures, among whom man lives as an equal in all simplicity, fraternity, and happy comradeship.

Besides those that have been named, the most important essayists in the natural-history field have been Americans. As this is a study primarily of English literature, and not of American, it is unnecessary to discuss them here. There is, further, an adequate treatise on this phase of the subject.[12] Yet it might be well to mention very briefly a few of the most eminent.

The father of American ornithology, John James Audubon (1780-1851), was not content with painting exact portraits of birds, with writing exact descriptions of them. His "Ornithological Biography; or, an Account of the Habits of Birds of the U.S.A." (1832) is solemnly, poetically written, with rather too much of a tendency to use hackneyed phrases, supposedly "sure-fire" for literary effect. Yet there is charm and power in the book, while his journal of travels [13] is even more fascinating to the general reader. At about the same period (1833), Dr. John Godman, confined to his bed by illness, wrote from recollection of his walks and observations. His book, "Rambles of a Naturalist," issued posthumously, is artificially lofty like the work of Audubon, which it resembles

[12] Philip Marshall Hicks, "Development of the Natural History Essay in American Literature." University of Pennsylvania, 1924.
[13] "Delineations of American 'Scenery and Character.'"

in its pleasant, honest account of nature, though it cannot even approach that work in scientific importance or originality.

Henry David Thoreau (1817-1862), best known and perhaps truly great as philosopher, was a naturalist incidentally but very sincerely. Like Jefferies and Hudson, he was concerned over man's soul and saw its only redemption in returning to the simple life which can be best practised amid natural surroundings. Putting his theory to the test, he set up a hermit-existence beside Walden Pond, near Concord, the fruit of which experience may be found in his "Walden" (1854), a perfect example of the complete harmony of nature-descriptions with philosophical and moral reflections. The same spirit can be found in his other works: "A Week on the Concord and Merrimac Rivers" (1849), and the posthumous "Excursions," "The Maine Woods," "A Yankee in Canada," "Winter," "Early Spring in Massachusetts," "Summer," "Autumn," "Miscellanies," "Cape Cod," not to mention the Journal, upon whose pithy, accurate entries all the rest is based. More than any of the others, Thoreau believed in and worshipped wildness as a tonic for men, nor, as some others have done, did he accept wildness incidentally because it is a part of nature. He chose it for itself.

John Burroughs (1837-1924) is about the most popular of the natural-history essayists. For many years his gaunt, muscular figure and patriarchal beard symbolized nature-in-America, while volume after volume of mellow, genial studies emanated from Slabsides, his retreat in the Catskills. He first aroused notice in 1871 with "Wake Robin." Some of his leading books are "Birds and Poets" (1877), "Locusts and Wild Honey" (1879), "Pepacton" (1881), "Riverby" (1894), "The Light of Day" (1900), "Far and Near" (1904), "Ways of Nature" (1905), "Leaf and Tendril" (1908), "The Breath of Life"

(1915). His early study of Walt Whitman was an inspired incursion, almost prophetic. In general, his work, always competent and often charming, tends to be too level; it is a trifle mediocre. He has been called "the Longfellow of naturalists."

Associated with him in some of his travels was John Muir, whose "Boyhood of a Naturalist" (1913) and "Steep Trails" (1918) are very widely read. Muir was a self-conscious literary artist. His rather elaborate writing is sometimes marred by an excessive tendency to moralize and sentimentalize, where most naturalists would merely describe. Among recent and living naturalists, Dallas Lore Sharp ("The Spirit of the Hive," 1925) and David Starr Jordan ("Story of a Salmon" and others) stand out prominently. William Beebe, thoroughly professional ornithologist and all-round field naturalist, has been unusually successful in volumes of essays and travel-journals: "Jungle Peace" (1918), "Galapagos—World's End" (1924), "The Arcturus Adventure" (1926), "Jungle Days," and "Pheasant Jungles" (1927). He is the author also of solid treatises on pheasants and on birds, physiologically considered.

Jean-Henri Fabre (1823-1915), so-called "Homer of the Insects," wrote a whole shelf of delightful books, probably the best of their kind, depicting "Social Life in the Insect World," "The Mason-Bees" (1914), "The Life of the Caterpillar" (1916), "The Hunting Wasps" (1916), and so on. More than any other he has achieved an inside view, thoroughly sympathetic, of those complex little creatures. The famous Belgian poet, Maurice Maeterlinck, tried his hand at the same craft in "The Life of the Bee" (1909), in which close observation is alternated with an unexpected mysticism. His "Life of the White Ant" (1927) shows the same qualities.

These are some of the leaders in that division of scientific literature which is most widely recognized as belong-

ing to the true body of letters. It constitutes a delightful province, especially refreshing to the mind of one who has had the world too much with him, who is weary of studies of social conflict and personal analysis. It restores the mind with a sense of the reality of the true, old things, and it enriches the mind with a supply of unclassified but fascinating odd trifles about that nature which it is the object of science to uncover and understand.

CHAPTER XXIII

UNITY OR PLURALITY? IS LIFE LIMITED TO THE EARTH?

Little has been said so far concerning astronomy, though the study of heavenly bodies is one of the oldest of sciences, perhaps the most nearly perfected of all. Astronomy had reached the stage of being able to predict phenomena centuries ago, a stage at which most other sciences have not yet arrived. Its great generalization was formed by Newton in the late seventeenth century, nearly two hundred years before Darwin performed a like service for biology. Naturally, then, the recent history of this branch of science is both more technical and less spectacular than that of some others, which tends to make it less convenient material for literary treatment. Apart from all these reasons, mere lack of space requiring that something be omitted, it has been found expedient to omit astronomy.

There is, however, a minor and essentially unimportant phase of astronomical theory that has an uncanny appeal to the human imagination. In one sense, the question of whether life exists elsewhere than on our earth is not a legitimate scientific question at all, since there is not yet any opportunity for direct observation and verification. All the reasoning on both sides must proceed on a basis of rather trivial, certainly insufficient fact. The conclusion arrived at seems to have resulted in each case rather from the particular author's temperament than from any objective evidence, the more sanguine and the more emotionally religious men concluding that other

bodies are inhabited while those who incline to pessimism or to a conservative theology seem generally to have chosen the belief that there is no life elsewhere. Yet many real astronomers, including some of the most interesting personalities in the history of science, have ventured to write upon this subject. Lively disputes have taken place, and memorable passages have been penned. Remembering always that it is a whirlpool and not a main current in the scientific stream, we shall find it worth-while to glance at some parts of the discussion of this question. Incidentally, it provides an opportunity to note some outstanding men and their work.

Ancient philosophers had to some extent considered this matter. One of them, indeed, had earned contempt and ridicule by suggesting that the moon might be as large as all Greece. Aristotle, we are told by Bishop Wilkins,* could not give any good reason against the habitability of the moon, though he tried, being eager to please his master Alexander, whose ambition would have tortured him had he supposed there was any world left unconquered! So the good bishop wrote his own view of it, entitled "The First Book The Discovery of a New World or a Discourse tending to prove, that 'tis probable there may be another habitable World in the Moon. With a Discourse concerning the possibility of a passage thither." This book, first issued in 1638, was admittedly "not . . . any exact, accurate Treatise, since this discourse was but the fruit of some lighter studies, and those huddled up in a short time," yet it is quite serious—and an odd, delightful example of primitive scientific book-making. It is divided into a number of propositions, like those of a mediæval disputation, each of which is vigorously demonstrated by reference to the most unexpected authorities: Church fathers—quoted in Latin—, ancient philosophers, scholastics such as Scaliger,

* (1614-1672.)

the Scriptures—quoted in Hebrew—, as well as "Galileus, Keplar," and other astronomers. Several of the early chapters are devoted to refuting the objections. . . . The author puts forward as the basis of the first chapter his conviction that "the strangeness of this opinion is no sufficient reason why it should be rejected." With all the earnestness in the world and with considerable energy and scholarship, he then proceeds to prove that at times strange ideas have proven true. Proposition four brings us to some definite discussion of the moon as a "solid, compacted, opacous body," after which it appears that "the Moone hath not any light of her owne," that "there is a World in the Moone" with bright parts and spots representing land and sea, with "high Mountaines, deepe Vallies, and spacious Plaines which our posterity may some day visit," and finally "That 'tis probable there may be inhabitants in this other World; but of what kinde they are, is uncertain." All in all, it is a quaint, erudite, garrulous mass, yet in its attack upon prejudiced thinking and in the commonplace facts set forth aggressively it supplies a gauge of the advance of science since that time.

The opposition that Bishop Wilkins anticipated and tried to fend off came. Samuel Butler, author of "Hudibras," turned his biting wit against the bishop in a rugged screed entitled "The Elephant in the Moon," which depicts a gathering of scientists agog upon seeing that terrestrial mammal in our satellite merely because a mouse had somehow found its way into the telescope tube. Two centuries later Professor Adam Sedgwick could find nothing harsher to say against Darwin's evolutionary idea than that it was as wild as Bishop Wilkins's. That early theorist was furthermore the author of a "Discourse concerning a New Planet" (1640), "Mercury or the Secret and Swift Messenger" (1641), and an "Essay towards a Real Character and a Philosophical Language" (1668).

He was one of the group that founded the Royal Society.

On the Continent others were battling over the problem. Fontenelle in 1686 wrote his "Conversations on the Plurality of Worlds." Huyghens followed with his "Cosmotheros"—"Theory of the Universe or Conjectures Concerning the Celestial Bodies and their Inhabitants" (1698). Both of these great men favored the belief, as apparently did most of the distinguished astronomers down to the nineteenth century. Even Dr. Chalmers, giant ecclesiastical organizer and respectable though unspecialized scientist, maintained the same view in his "Astronomical Discourses." In 1820 Alexander Maxwell wrote a volume on the "Plurality of Worlds" which attacked all astronomy and even Newtonian principles as "atheistical . . . destructive poison."

The first great astronomer to touch upon this question during the Victorian period was Sir John Herschel.* By inheritance as well as by his own ability, Sir John had become the uncrowned king of the astronomical commonwealth and an imposing figure throughout the scientific world.[1] Equipped with every opportunity to learn—including a forty-foot telescope, the greatest then in existence,—he made distinguished contributions to astronomy, chemistry, and the new art of photography. He continued, perfected, and completed his father's study of the construction of the heavens by recharting the observable stars of the northern sky and by adding those visible only in the Southern Hemisphere. This involved a residence of eight years at the Cape of Good Hope, and ultimately (1874) bore as harvest a posthumous "Catalogue of 10,300 multiple and double stars arranged in the order of right ascension." [2] Early in life (1826) he had prepared an essay "On the Parallax of the Fixed Stars,"

* (1792-1871.)

[1] See Chapter XI, above.

[2] Edited by Main and Pritchard.

which was followed in 1831 by his much discussed, influential "Preliminary Discourse on the State of Natural Philosophy."

In 1833 Herschel published a dignified popular "Treatise on Astronomy" in which, after describing the earth, the heavens, the planets, the sidereal system and the instruments used in their study, the author takes up the question of whether life can exist elsewhere than on earth. He first shows most clearly why there can be none on the moon; there is neither water nor air on the satellite. In commenting upon Saturn, he stresses the vast differences between the several planets of the sun's family. Seeming to assume by implication that each one has its own inhabitants, he glides into a passage of marvelling at the "Benevolence and Wisdom presiding over all." [3] In discussing gravitation at the surface of Uranus, he declares that under those conditions "giants might exist; and those enormous animals. . . . But of such speculation there is no end." He is, in short, not very definite in opinion; like a true scientist, he neither affirms nor denies what he has no means of testing. He is interested in the question, but rather smiles at the attempt to solve it, yet no infidel, he does not hesitate to use the possibility as a trope in praising Providence.

Other popular works of his are at least equally valuable. There are his "Outlines of Astronomy" (1850), "The Telescope" (1861), and above all the urbane, charming, stimulating "Familiar Lectures on Scientific Subjects" (1867). The first three of these lectures were delivered in the village school of Hawkshurst, Kent, yet they were composed with as great care, erudition, and literary art as though they had been planned for most brilliant audiences. Later they were published in "Good Words" and eventually republished in book form. These vividly presented, eloquently phrased, sculpturally

[3] "Treatise on Astronomy," pp. 263, 271.

modelled lectures deal with both geology and astronomy, and in both fields the orator persuasively indicates the hand of Providence. Even the earthquake and the volcanic eruption, those most terrible of disasters, are shown to have their uses, indeed to be indispensable. Other topics treated are the absorption of light and the calculation of chances.[4]

It might be supposed that Herschel had made his attitude—if not emphatic—sufficiently clear. But not long afterward a strangely un-Herschelian screed made its appearance. It was called "Great Astronomical Discoveries Lately Made by Sir John Herschel, LL.D., FRS., etc., at the Cape of Good Hope." It appeared in 1837 in the New York *Sun* ostensibly reproduced from the *Edinburgh Journal of Science.* No one acknowledged authorship, Richard Adams Locke, who actually wrote it, trading upon the fame of Herschel, to carry the hoax to success. It begins with an account of the great telescope and mentions many internationally renowned savants by name as having participated in the researches described. In a style half imitation science, half circus-poster superlative pomposity, the anonymous author tells how he and Herschel turned the "hydro-oxygen reflectors" upon the moon and saw there cliffs of a "basaltic rock," a flower like the "rose-poppy," "a verdant declivity of great beauty . . . a lunar forest, . . . yews . . . a level green plain . . . as fine a forest of firs, unequivocal firs as I have ever seen cherished in the bosom of my native mountains . . . a lake or inland sea . . . continuous herds of brown quadrupeds" like deer, as well as unicorns, pelicans, "nine species of mammalia and five of oviparia," and last but not least, human beings equipped with wings and, even as seen through a telescope at a distance of 240,000 miles, "eminently happy and polite."

This pseudo-scientific moon hoax was intended for the

[4] He was the author also of works on navigation.

public and aroused no more interest among the illuminati than it deserved. But the old dream continued and emerged again in 1853 in the form of an anonymous essay,[5] actually written by William Whewell, Master of Trinity College, Cambridge, and author of the history and philosophy of inductive sciences.[6] Whewell was a capable mathematician, careful reasoner, sincere theologian. Though the character of the subject was such as to make him feel it wise to conceal his authorship, one might feel sure that this would be no hoax but a serious, honest attempt to answer an unanswerable question as truthfully as possible, however disagreeable the result. For Whewell concluded that, practically speaking, life is not possible anywhere else than on earth. Jupiter, it is true, may have "cartilaginous and glutinous masses"; Venus may contain "microscopic creatures with siliceous coverings"; but apart from these unimportant possibilities, "Earth, alone, is placed at the border where the conditions of life are combined. . . . The Earth's orbit is the Temperate Zone of the Solar System."

Now, Whewell reached this conclusion after studying "the best authorities and the most recent discoveries," astronomical, microscopical, geological. He knew that some persons—Dr. Chalmers, for instance,—held it a necessary corrolary of faith to suppose that the Creator had set inhabitants upon all the worlds. Whewell was a religious man and naturally he strove to show that his own view was not inconsistent with true faith. It is evident, however, that he knew well how impossible it is for a scientific thinker to reconcile his system of thought with a perfect and simple fundamentalist creed. A large part of the book is given up to "the argument from design." Says Whewell, "There is no more worthy or suitable employment for the human mind than to trace

[5] "Of the Plurality of Worlds, An Essay."
[6] See above, Chapter XX.

the evidences of Design and Purpose of the Creator, which are visible in many parts of the Creation. The conviction thus obtained that man was formed by the wisdom, and is governed by the providence, of an intelligent and benevolent Being, is the basis of Natural Religion, and thus of all religion." But he argues forcefully and with illustrations drawn from many fields that often "so far as we can see, the structure answers no purpose . . . but exists for the sake of similarity. . . ." So, too, the similarity of planets to the earth is no proof that they are endowed with life; they "had no vital tendencies; they could have had such given only by an additional act, or a series of additional acts, of Creative Power," and we all know that "it is not the rule followed by the Creator, to fill all places with living things." His stiff, rhetorical essay thus proved that science gives us no reason for supposing that there is life elsewhere in the universe and that religion gives us no reason for wanting to suppose it.

This conclusion profoundly shocked another eminent physicist, Sir David Brewster,[7] who stumbled upon the book without being aware of its authorship. Soon he wrote, and John Murray published, a volume which was a sort of brief in rebuttal—"More Worlds than One the Creed of the Philosopher and the Hope of the Christian" (1854). Admittedly he was stimulated to this effort by the other volume's "elaborate attack upon opinions consecrated, as [he] had thought, by Reason and Revelation." These two personified faculties preside throughout Brewster's own book, which is a more thorough treatise on astronomy and at the same time a more rhapsodically, more emotionally spiritual discourse. Of the seventeen chapters, fourteen might be studied with profit as the text of an elementary course in astronomy. One deals with religious aspects of the question, one with objections

[7] For Brewster's other work, see Chapter XXI above.

from the nature of the planets, and one with the future of the universe.

It is not necessary to comment in detail on the purely astronomical chapters. They are composed of familiar factual material told with much clearness and considerable elegance and charm. The religious portions suffer from the weakness that must afflict all such argumentation—they assume to know the will of the Creator, using that supposed knowledge as a basis for reasoning. They contain much that is pure fancy, and are very largely written in elaborately ornamented style. A dozen scriptural books are cited to show that Revelation uses "terms which clearly indicate that the celestial spheres are the seat of life." For instance, the planets are referred to (in Hebrews) as "chambers of the south." Whereupon, and upon a scrutiny of the observable condition of the several planets, Brewster concludes that the heaven of man's future existence is to be looked for upon some heavenly body. "Man in his future state of existence is to consist, as at present, of a spiritual nature residing in a corporeal frame. He must live, therefore, upon a material planet, subject to all the laws of matter, and performing functions for which a material body is indispensable." [8] Of course, such life need not be exactly what we know as human; may it not, perhaps, include "a type of reason to which the intellect of Newton is the lowest degree"? In answer to Whewell's suggestion that earth may have been selected as the single abode of life so that a redeemer might be sent here, in answer to the implied ridicule of the idea that a redeemer must then be sent to all inhabited worlds, Brewster replies that the perfect beings of the other worlds need not be saved, for they may be without sin.

Brewster having thus boldly acknowledged his own partly unscientific blows in the combat, Whewell prepared

[8] "More Worlds than One," pp. 12, 14, 73, 147.

to do likewise. First he replied by means of "A Dialogue on the Plurality of Worlds"—signed this time and subtitled, "supplement to the Essay on that subject." Here, in a conversation between A and Z, the latter being the author's spokesman, recent objections to his ideas are summed up and answered. On the whole a tedious book made up largely of old ideas repeated, it yet contrives to say a few things pointedly and very sanely. For instance: "I only proposed to show that this notion has been taken up on insufficient grounds," and "I do not pretend to know for what purpose the stars were made." To such obviously sensible remarks, Brewster could not find an adequate rejoinder, or at all events he let the matter drop and turned to more practical researches.

Thus the question was allowed to rest until new discoveries lent fresh material to it by supplying further facts for interpretation. In 1859 Kirchhof and Bunsen perfected the spectroscope. With this useful little instrument, it was now possible to discover something about the actual material make-up of distant stars, and presently a so-called "new astronomy" came into being. In 1862 Huggins measured the position of lines in the spectra of forty stars and in 1864 presented evidence to show that some nebulæ were really star-dust and not mere clusters of stars so distant as to seem like fiery clouds. Herbert Spencer, ever abreast of advance, contributed his article on "The Constitution of the Sun" to *The Reader* in 1865, and two years later Professor Newton showed the November meteor-shower to be recurrent. In 1870 Richard A. Proctor (1837-1888) published his "Other Worlds than Ours—the Plurality of Worlds Studied Under the Light of Recent Scientific Researches."

Proctor was a most gifted as well as learned popularizer. He had previously (1868) produced a competent volume of essays—"Light Science for Leisure Hours" ("A Series of Familiar Essays on Scientific Subjects, Natural

Phenomena, etc."). The subjects treated were the aurora, the earth as a magnet, our chief timepiece—that is, the moon,—losing time, recent solar researches, and the Gulf Stream viewed as a myth. The later editions of this book included a vigorous essay on the usefulness of earthquakes. The last named work followed one of Sir John Herschel's. The truth is that Proctor was a devoted admirer of that great man, of whom he once said[9] that though "the literary merits of his writings are certainly not exceptionally great" yet he "could so touch the dry bones of fact that they became clothed at once with life and beauty." Some of his essays dealt with Herschel's life, his work, and his position as a theorist. There was a sort of hero-worship in all this, the humble, not very original, practitioner of astronomy making all he could of the socially and professionally fortunate one. Yet Proctor's own skill and aptitude at writing scientific exposition for the general reader made him recognize his master's inferiority such as it was.

Proctor was ever keenly attentive to the demands of clear and striking style. Like Tyndall and some others, he recognized the need of imagination in scientific work. Said he:[10] "A man may have at his fingers' ends the distances, volumes, densities, and so on of all the planets, the rates at which they move, the physical features they present, and a hundred other facts equally important; but, unless he has in his mind's eye a picture of the solar system, with all its wonderful variety, and all its yet more amazing vitality, he has not yet passed even the threshhold of the science." He himself attempted to convey that picture in all its variety and vitality in his several works, including "Half Hours with the Telescope" and "Essays on Astronomy; a Series of Papers on Planets and Meteors, the Sun and Sun-Surrounding

[9] From "Essays on Astronomy," p. 1.
[10] "The Study of Astronomy," p. 37.

Space, Stars, and Star Cloudlets, and a Dissertation on the Approaching Transit of Venus" (1872). He attempted it in his treatment of the plurality of worlds—"Other Worlds Than Ours."

That book is an unusually full and satisfactory example of both the strictly scientific and the teleological methods of arriving at a conclusion. The author constantly writes as though each celestial body of necessity had some assigned "function" to fulfil in the great scheme of things. He even argues upon the basis of that idea. Plainly he is a religious man who cannot stop short of the belief that there is a coherent purpose in the cosmos. Yet he does not allow that to influence his statement of fact or the clarity of his reasoning. Considerable bodies of detail are called to give their testimony, and when the testimony is adverse, the honest scientist does not hesitate to point out that fact. His expression is very concrete and very clear, so unmistakable that any errors in it must be evident. In sum he concludes that the planets Venus and Mars are probably inhabited, as are the satellites of the "heat-sun" Jupiter and those of Uranus and Neptune and possibly some planets revolving around certain of the outer stars. "Shall we," he asks persuasively, though admitting that it is just short of being proof, "recognize in Mars all that makes our own world so well fitted to our wants—land and water, mountain and valley, cloud and sunshine, rain and ice and snow, rivers and lakes, ocean-currents and wind-currents, without believing further in the existence of those forms of life without which all these things would be wasted?"

Shortly the most determined and most objective brief for celestial life was to be based upon the condition of Mars. Our nearest neighbor, except the moon, that planet can be most completely studied in detail. It is the only planet whose solid surface has been observed with any great degree of certainty, for all the others seem

to be surrounded with envelopes of gases and clouds. There are rather detailed maps which show many natural features of what appear to be lands, seas, desert. Sometimes masses of cloud—or dust—form and temporarily hide part of the planet from view. The poles gradually turn white and dark during the course of the Martian year, and they change alternately, leaving little doubt that our astronomers are witnessing the progress of the seasons on Mars, the accumulation of snow and its melting.

But the strangest feature is one which has no earthly counterpart. Running in perfectly straight lines across the planet for hundreds, or even thousands of miles, are vast "canals." These were first seen in detail [11] in 1877 by Schiaparelli, who called them "canali" without being able to explain their existence. In 1881 he noted that several of them were double, running like "the rails of a railway track" side by side. Most of them radiate from the snowy poles, and where two intersect there are seen small dark spots, first noted by Pickering in 1892.

Professor Percival Lowell* made a special study of these canals. He established an observatory in the clear atmosphere of Flagstaff, Arizona, charted Mars, and eventually issued his theory that the canals of Mars were "non-natural features." They had been produced, he maintained, by intelligent, purposeful beings in order to convey the water of the melting polar snows to other parts of the planet, most of them barren, and thus to cultivate plants by irrigation. This theory was further borne out by the fact that as the polar white diminishes, a blue fringe creeps along the canals at a uniform rate toward, and sometimes even past, the equator, and at the same time dark, bluish, or greenish patches spread over the otherwise red surface of the land. This is taken to be the formation of seasonal rivers, lakes, swamps, and cul-

[11] Dawson had seen some canals in 1864. * (1855-1916.)

tivated fields under the influence of the artificially transported water. Professor Lowell expounded these views in a series of volumes, the most notable being "Mars as the Abode of Life" (1908), his little book, "The Solar System" (1903), based upon six lectures at the Massachusetts Institute of Technology, and "Mars and its Canals" (1906).

Professor Lowell did not maintain that there are men on Mars. "It is certain," he declares, "that there can be no men there; that is as certain as anything well can be. But this does not preclude a local intelligence equal to, and perhaps easily superior to, our own. We seem to have evidence that something of the sort does exist there at the present moment, and has made imprint there of its existence far exceeding anything we have yet left upon mother Earth."

So radical a doctrine was bound to meet with opposition. Miss Agnes Clerke, author of the "History of Astronomy during the Nineteenth Century" (1885) and "The Herschels and Modern Astronomy," objected almost as soon as the first sketches of it appeared.[13] She maintained that in the thin atmosphere of Mars there could not be enough water-vapor to make irrigation worth the expenditure of effort. The snow, she thought, was very light and fluffy, as indicated by the great rapidity with which it melts; hence its melting could produce but little water. This line was taken further by Wallace, of evolutionary fame but at this time a rather disputatious old man. He treated the question in two books, "Man's Place in the Universe" (1902) and "Is Mars Habitable?" (1907). The latter essay disagrees with Lowell in each particular; according to Wallace, there is not enough air about Mars to support animal life; the "snow" of the two poles may be not frozen water at all but frozen carbon-dioxide; the clouds are probably not water-vapor but

[13] See her "Problems in Astrophysics" (1903).

dust; the blue tint seen along the canals is not a sign of water but of dust; the canals themselves are merely great cracks in the surface of the planet. In this Wallace follows the meteoritic theory of Sir Joseph Norman Lockyer, which holds that the planets were formed by the agglomeration of numerous meteorites. The earth was formed of so many that it developed an internal heat which broke the surface into hills and valleys, seas and cliffs, but the smaller Mars soon cooled at the core, leaving a molten shell to split along straight lines as it, too, solidified. According to him, the oases are merely the fuller breaks caused by the intersection of two or more fissures. There is nothing non-natural about it, and therefore no reason to suppose life on Mars.

Wallace's earlier book is the fuller. Like Brewster's and Proctor's discussions of the same subject, he uses the question of unity or plurality of worlds as a frame for the exposition of a rather thorough account of astronomy, whose "novelty consists in combining the various results of . . . different branches of science into a connected whole so as to show their bearing upon a single problem —a problem which is of very great interest to ourselves."

Wallace does accomplish one very remarkable feat; he states the case for the habitability of each planet separately and so fairly as almost to convince the reader, before proceeding to demolish the case by his further remarks. He goes beyond any of the others whose opinions have been considered, out of the solar system altogether, to study the distant stars with a view to their habitability. His conclusion is that nowhere in all space is there life except on earth. Why? Apart from the fact that the proper combination of conditions does not exist elsewhere, Wallace—in old age a spiritualist—suggests a mystical reason: our earth is neither large nor small as planets go; our sun is just a good, average middle-class star; the earth occupies a middle position in the solar

system between the "inferior" and "exterior" planets; our solar system seems to be placed midway in that stream of star-systems called the galaxy or milky way. Perhaps, as the ancients believed, our little earth is somehow the real centre of the universe; perhaps that is why it has been selected as the sole seat of life.

He was not entirely successful. For one thing, Wallace was not himself a practising astronomer, but a biologist, and had to base all his arguments upon reading and a kind of brilliant, theoretical argumentative reasoning of which he was master. His choice of the meteoritic hypothesis was unfortunate, for that doctrine has been widely opposed. Furthermore Wallace was old; there is a note of petulant, impotent indignation in these later writings that irritates despite the vividness of his style. Lowell, in his later work, answered the objections but did not accept them. Professor William H. Pickering, whose criticisms of Lowell are cited by Wallace almost gleefully, continued to suppose that on Mars at least vegetable life must exist; that even if water is too scarce on Mars to be "husbanded," the canals may serve some other useful purpose; that even if the canals are natural, they may be the means of irrigation. The question is one of those that are still unsettled, some astronomers preferring one view, some the other. For example, C. E. Housden's "The Riddle of Mars the Planet" (1914) unreservedly accepts Lowell's hypothesis, though the same conclusion is reached by a different course of reasoning.

But if Wallace were alive today, he would undoubtedly be cheered by the recent acclaim given to Professor Chamberlain for his exposition of the "planetesimal" theory, which explains the origin of the solar system much as the meteoritic theory did, and by the recent discussion of the whole question at the competent hands of Professor Arthur Stanley Eddington of Cambridge.[18] This short,

[18] Author of "The Nature of the Physical World."

super-popular magazine article, "Man's Place in the Universe" (*Harper's*, 1928) declares, on the basis of spectroscopic retardation of light, that the universe is finite, and the total number of possible homes for life strictly limited. Earth is entirely peculiar in possessing a relatively huge moon, whose breaking away from earth [14] left a great gap, now filled with water. Had this not happened, our globe would be quite covered with water, as presumably Venus now is. Furthermore our solar system is peculiar. Dr. Eddington seems to hold that the normal system consists, not of a central sun surrounded by a family of planets, but of a double star, two nearly equal bodies revolving about a common centre of gravity—an arrangement presumably unsuited to the development of life. "The solar system is not the typical product of development of a star; it is not even a common variety of development; it is a freak." Last, he estimates according to the calculation of probability that the chance that the conditions necessary for life would exist on two or more bodies *at the same time* must be negligible. Says he, "If indeed she (Nature) has no grander aim than to provide a home for her greatest experiment, Man, it would be just like her methods to scatter a million stars whereof one might haply achieve her purpose. . . . I presume, however, that at the end of the weeding out there will be left a few rival earths dotted here and there about the universe . . . where consciousness has already vanished or is yet to come," though we may comfort ourselves with the reflection that "at the present time our race is supreme."

At the moment, this is the last word in a controversy that has been conjectural and temperamental almost from the start, that stirs the imagination mightily, that has given much food for thought though little means of final determination, and that has provided several of the

[14] According to Sir George Darwin's explanation.

most skilled scientific writers with a framework upon which to construct their explanations of astronomical phenomena. It has thus served as what modern educators call the "project method" of teaching, which makes the study of some subject appear to be subservient to some whole and significant activity, while actually its best results have been in leading the student to take an intellectual interest in the subject. As the youngster gladly studies arithmetic and geometry to help him build a tool-chest, older and more sophisticated readers have learned the habitudes of heavenly bodies in a vain endeavor to make friends with other assumedly human souls being whirled past us through space.

NOTE

The foregoing chapters indicate a few of the paths that lead through the immense and all but unknown province of the literature of science. Along some of these paths I have gone a little way, along many not at all; none have been explored in their entirety.

What I hope has been accomplished is the following: attention has been called to the existence of such a division of literature, a division generally unrecognized, sometimes denied; a part of its history has been traced; a part of its technique has been explained; a body of fact and opinion dealing with this subject has been gathered and repeated.

This is not intended, nor does it pretend, to be a definitive treatment of scientific literature, nor even of that body of natural-history literature which it more especially treats. It is sent forth as a sort of first call. If it is soon superseded by better, more thorough, more complete, more balanced works, the author will be satisfied, for that will prove that the faith he has staked upon the literature of natural science is justified.

QUESTIONNAIRE ON THE LITERATURE OF SCIENCE

and a Summary of Answers Received [1]

1. In your opinion is there an essential contradiction between literature and science?

   Yes, 4. No, 12. Qualified, 4.

   "No contradiction but an essential distinction."

   "No contradiction but different aims."

   "Temperamental antagonism . . . impatience of literary men."

2. (a) Do you consider a "literary" character to be harmful to the scientific standing of a book on some scientific subject?

   (b) Would you make an exception for books of popular science?

   (a) Yes, 3. (a) No, 12. Qualified, 1.

   "No, if literary quality means good style, etc."

   (b) Yes, 3. (b) No, 16.

   "If more is meant than clearness of exposition, literary quality would not be an advantage scientifically, but certainly not a disadvantage."

   "Some of the classics of science are real classics in the literary sense."

   "Not unless truth is sacrificed to style."

   "Yes, if by standing is meant the prestige the book attains among scientists."

3. Do you consider literary quality an advantage in a book on scientific subjects?

   Yes, 15. Qualified, 1. No, 0.

   "Literary quality is a distinct advantage. A scientific treatment without literary qualities is less readily accepted than one which has."

[1] See Introduction. This questionnaire was answered by about twenty-five representatives of the various sciences and of literature.

4. What book (or books) of science stand out in your recollection as especially memorable?

Darwin, "Origin of Species," 3.
Whewell, "History of Inductive Sciences," 1.
Lowell, P., "All Works," 1.
Huxley, 6.
Tyndall, 2.
Fabre, 1.
Pupin, 2.
Langley, "New Astronomy," 1.
Russell, B., 1.
Thorpe, "Essays Hist. Chem.," 1.
Bragg, "Concerning the Nature of Things," 1.
Abbott, "Earth and Stars," 1.
Thomson, J. A., 1.
Slosson, "Creative Chemistry," 1.
De Kruif, "Microbe Hunters," 1.
Spencer, 1.
Loeb, J., 1.
Bayliss, 1.
Wilson, E. B., 1.
Mach, E., "Analysis of Sensations and Mechanics," 1.
Boule, M., "Fossil Man," 1.
Pearson, "Grammar of Science," 1.
Haeckel, "Natural History of Creation," 1.

5. Was the writing of it (them) as distinguished from the subject-matter, of importance in making the impression on you which this book (these books) achieved?

Yes, 12. Qualified, 2. No, 0.

6. Do you recall any specific qualities (of style, author's attitude, imagination, humor, emotion, illustration, etc.) which seemed worth while in it? Please give details.

Quality	*No. Naming*	*Quality*	*No. Naming*
Humor (Mach),	4	Fervor (Haeckel),	1
Combativeness (Pearson),	1	Quality,	1
Precision,	1	Form,	1

Logical Organization,	1	Ease,	1
Rhythm of Diction,	1	Force (Without Emotional Stress),	1
Good Expression,	1		
Argument,	1	Simplicity,	1
Lucidity,	3	Not Tedious,	1
Sane,	1	Human,	3
Style,	4	Author's Attitude,	3
Illustration,	3	Imagination,	3
Emotion,	2	Allusion,	1

7. In your opinion, is the very free use of technical and specialized terminology by scientific writers an advantage or a disadvantage?

Advantage, 4. Disadvantage, 7. Qualified, 5.
"A disadvantage only for the layman."
"Depends on the audience."

8. Do you know of any scientific writer, past or present, who managed to write in a thoroughly scientific and dependable manner yet made a sparing use of such terms? Please name him and one of his books.

Author	*No.*	*Author*	*No.*
Huxley,	4	None,	2
Tyndall,	2	La Place,	1
Tylor, "Primitive Culture,"	1	Kroeber, "Anthropology"	1
Darwin, "Origin,"	3	Wheeler, "Ants,"	1
Humboldt,	1	Wallace,	1
Slosson, "Creative Chem.,"	1	Burroughs,	1
Mills, J., "Radio Engineer,"	1	Fabre,	1
Van Nostrand Series,	1	Bergson,	1
Bragg, "Creative Knowledge,"	1	Lowell, "Mars and Its Canals,"	1

9. Would you be theoretically in favor of a scheme to simplify and regularize the nomenclature of botanical and zoölogical species, if such a scheme could be devised?

Yes, 7. No, 4. Qualified, 5.

10. Do you consider that, generally speaking, works of so-called "popular science" are undependable?

Yes, 8. No, 6. Qualified, 5.

11. Do you know of any particularly fine books of "popular science?" Please give names.

Author	*No.*	*Author*	*No.*
None,	1	See "Reading with a Purpose,"	2
Mach, "Pop. Lectures,"	1	Huxley, "Essays,"	5
Tyndall, "Essays,"	3	Faraday, "Essays,"	1
Dorsey, "Why We Behave,"	1	De Kruif, "Microbe Hunters,"	3
Altenburg, "How We Inherit,"	1	Harrow,	1
Humboldt,	1	Darwin,	1
Wallace,	1	Slosson,	1
Mills,	1	J. A. Thomson,	1
Van Nostrand Series,	1	Eddington, "Stars and Atoms,"	1
Lowell, "Mars Abode of Life,"	1	Flammarion,	1

12. (Optional) What is your own field of major interest?

Literature,	3	Anthropology,	2
Physics-Chemistry,	2	Biology,	2
Protozoölogy,	1	Nat. Sc. Education	1
Popular Sc.,	1	Astronomy,	1

13. Do you know of any book devoted to a criticism, evaluation, or history of scientific literature regarded primarily as literature? Please give names.

No, 10. No Ans., 5. Yes, 2. De Kruif, Harrow (history).

14. Are there any suggestions you would make as to the desirable elements of style in writing on scientific subjects? Any cautions as to what should be avoided?

See "Science Service" Hints.
Avoid the journalistic, trifling, 2.
Lucidity, 2.
Sparing use of special jargon.
Concreteness.

Connections of the subject with larger concerns of mankind.
Knowledge of English and more experience in writing clearly.
Use Huxley as a model.
Care to hit capacity of expected reader.
Elimination of the unimportant.
Enthusiasm for scientific work.
Avoid exaggeration and dogmatism.
Many examples.
Brevity, 2.
Classification.
Vivid visualization.
Illuminating analogies.
More attention to style.
Guard against misleading impressions.
Avoid generalizations and muddled thinking.
Sufficient explanation to make point go home.
Lively imagination.
Humor.

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INDEX

The references given in the following index are to the text proper and do not include the questionnaire or the bibliography which can be looked through easily for any desired title or name.

Ælfric, 375.
Addison, Joseph, 75; "Dialogues upon Medals," 375.
Agassiz, Louis Jean Rodolphe, 57, 102, 141, 237, 135, 325-326; "Methods of Study," 326; "Essay on Classification," 326.
American Library Association, "Reading with a Purpose," 15, 374.
"Antiquity of Man" (Lyell), 58, 220, 240-242.
Archetype (Urthier), 96; (Geoffroy's), 116, 118; (Owen's), 143-147, 324.
Argyll, James Douglas Campbell, Duke of —; — and Spencer, 246; "Reign of Law," 256, 304; "Primeval Man," 256, 305; dispute with Huxley, 305; "Organic Evolution," 305.
Aristotle, 100, 293, 335.
Audubon, John James, 412.

Bacon, Francis, Lord Verulam, 149, 183, 335-339; —'s claims denied, 335; "Sylva Sylvarum," 336; "Great Instauration," 337, 338; "Advancement of Learning," 337; "Novum Organum," 337; literary style, 338-339; 350.
Ball, Robert Stawell, Sir, "Earth's Beginning," "Story of the Heavens," etc., 392.
Barnes, Harry Elmer, 25.
Barry, Frederick, "Scientific Habit of Thought," 30.
Bates, Henry Walter, 311-314; "Insect Fauna of Amazon," 312; mimicry, 313; "Naturalist on the Amazons," 313, 402.
"Beagle," 167-182, 191, 275, 402.
Bede (Beda Venerabilis), 375.
Beebe, (Charles) William, 414.
Belt, Thomas, "Naturalist in Nicaragua," 403, 404.
Bentham, George, 212-213.
Beowulf, 48, 177.
Bergson, Henri, 30, 364.
Biology, 20, 102-103; *also see* special topics.
Bonney, Thomas G., "Volcanoes," 392.
Boyle, Robert, "The Sceptical Chymist," 375.
Brain, W. Russell, 330.
Brewster, Sir David, 381; "Optics," "Heat," "Martyrs of Science," "Natural Magic," "The Kaleidoscope," etc., 381; "More Worlds than One," 423-424, 430.
Bridgewater, Francis Henry (Earl), 53-54, 348.
Bridgewater Treatises, 54, 122; Bell, Sir Charles, "The Hand, as Evincing Design," 178; Chalmers, Whewell, Kidd, Roget, Kirby, Prout, Buckland, 54, 348.
British Association for the Advancement of Science, 138, 142, 143-144, 232-237, 388.
Bronn, Heinrich Georg, 220, 237.
Brougham, Henry (Lord), 51, 123; "Objects, Advantages, and Pleasures of Science," 380-381.
Browne, Thomas, Sir, "Religio

Medici," 375; "Vulgar Errors," 375; "Urn Burial," 375.
Buckland, William, 41; His Bridgewater Treatise, 54; *"Reliquæ Diluvianæ,"* 41, 53; — and Miller, 133, 238, 308.
Buckley (Fisher), Arabella B., "The Fairyland of Science," 390.
Buffon, Georges Louis Leclerc, Comte de, mentioned by Irving, 63, 65-73; his irony, 67; his trial, 68-69; evolution, 69-71; style, 72-73; "Discours sur le style," 73; 100, 158, 159, 253.
Burroughs, John, 15; quotation, 62; 394, 396, 404; "Wit of a Duck," 396; 413-414; "Wake Robin," "Light of Day," "Ways of Nature," etc., 413.
Burton, Robert, "Anatomy of Melancholy," 398.
Butler, Samuel, "Elephant in the Moon," 418.
Butler, Samuel, 47; quotation, 62, 88; 106, 151.
Byron, George Gordon, Lord, 91, 222, 256, 341.

Cambridge, 26, 56; 147 note; 161, 165, 172, 222, 347, 422, 431; "Cambridge History of Eng. Lit.," 15.
Canby, Henry Seidel, 30.
Canning, George, with Ellis and Frere, "Loves of the Triangles," 81-83.
Cape Verde Islands, 168, 169.
Carlyle, Thomas, 48, 140, 291, 322.
Catastrophism, ch. II, 40-44, 47, 53, 55, 57, 114, 126, 142, 160, 182.
Chalmers, Thomas, 37, 41, 140, 238, 419.
Chambers, Robert, "Vestiges," 121-130; "Ancient Sea Margins," 122; authorship of "Vestiges," 122-123; his audience, 123; "Book of Days," 130; "Encyclopedia," 130; 131, 190, 381.
Chaucer, Geoffrey, 177, 179; "Tretis of the Astrolabie," 375.
Clerke, Agnes, 429.
Clifford, William Kingdon, 383-384; "Common Sense of the Exact Sciences," etc., 383-384.
Cobbett, William, "A Year's Residence in the U. S.," 402.
Cohen, Morris Raphael, 335.
Comte, Auguste (etc.), 20, 160, 342-347; preciseness, 342-343; "Plan for Scientific Works," 343; "Course of Positive Philosophy," 343; see "Positivism"; —'s classification of sciences, 344; "Treatise of Positive Polity," 345; "Catechism of Positivism," 345; the religion of Humanity, 345-347, 359; — and Huxley, 345, 347; — and Mill, 345, 347, 353; — and Spencer, 354, 358-360.
Conybeare, W. D., 52, 57.
"Creation by Evolution," 26.
Cuvier, Georges, Baron, 37, 41, 43; opposition to Lyell, 53, 97; "school of facts," 105-106, 115; discussion of 1830, 109, 113, 116, 118-120; "Discourse on the Revolutions of the Surface of the Globe," and other works, 113-114-116; style, 116; 121; — and Owen, 142, 143, 144, 159; 188, 237, 308.

Darwin, Charles Robert, 11, 20-21-22, 36, 72, 47, 379; opinion of Murchison, 55; 93; — and Lamarck, 100; opinion of "Vestiges," 121, 126, 148, 149, 153, 154, 159-280; "Autobiography," 159, 161, 167, 194; early life, 161; Humboldt and Herschel, 162-165; on the *Beagle*, 167-182; return, 173; "Journal of Researches," 170, 174-177; style, 175ff., 179, 197, 219, 274; first interest in evolution, 171-172; ill-health, 173, 185, 198, 202, 263; work growing out of voyage, 173-183; — and Owen, 178, 188, 324-325; "Geology of the *Beagle*," 178; "Coral Reefs," 179; "Geological Observations," 180-182, 270, 274; — and Malthus, 183-184; — at Down, 184-185, 198, 206, 271; marriage, 184; methods of work, 185, 203, 216, 273-277; "Formation of Mould," 185; four "Barnacle" (Cirripede)

essays, 185-187, 219, 275; two early essays on natural selection, 187-195, 206, 215, 251; plans for publication, 189; style, 187, 194-195; Linnean Society, 194; principle of divergence, 194, 200, 210; "Origin of Species," 194, 216-232, 263, 274; literary style, 215, 216, 228-232, 251-252, 266, 273-280; unfinished great book, 196-208, 215, 249, 256, 261; experiments, 201-204, 264, 267-269; Linnean Joint Paper, 208-214; abstract, 215, 261; — and Lyell, 168, 169, 188, 189, 197, 201, 217, 241; — and Hooker, 189, 197-198, 203, 224; reactions to "Origin," 219-225; —'s personality in writing, 230-232, 258, 267-268, 271, 278; botanical work, 249-250, 263-270; "Fertilization of Orchids," 250; "hobby-horses," 249, 259, 263ff.; "Variation under Domestication," 251-254; pangenesis, 254; "Descent of Man," 255-260; "Expression of Emotions," 259-262; "Climbing Plants," 263-265; "Insectivorous Plants," 265-267; "Cross and Self-fertilization," 267-268; "Different Forms of Flowers," 269; "Power of Movement in Plants," 270; "Formation of Mould through the Action of Worms," 270-271; style, 271; —'s death, 272; summary of —'s scientific and literary work, 272-280; technic, 275; structure, 276-277; weaknesses, 279; — and Huxley, 217-220, 233-236, 281, 284, 286, 291, 311, 319, 320, 367, 373; — and Hudson, 328.

Darwin, Erasmus, quotation, 62; mentioned by Irving, 63, 74, 92; life, character, 74-76; "Botanic Garden," 76-82; "Loves of Plants," 77-78; parody, 81-83; "Economy of Vegetation, 79-81; "Zoönomia," 83-89; "Phytologia," 89-90; "Temple of Nature," 90-92; 97, 158, 159, 161, 189, 223.

Darwin, Francis, Sir, 22, 194, 270.

Darwin, George, 263.

Daubeny, Charles G. B., 233-234.

Da Vinci, Leonardo, 39.

Davy, Sir Humphry, 11, 176, 375, 376-377; "Chemical Philosophy," "Safety Lamp," 376; "Consolations in Travel," 377.

De Kruif, Paul, 5, 14, 373; "Microbe Hunters," 24.

De la Beche, Sir Henry Thomas, 51-52-53, 381.

Descartes, Réné, 239.

"Descent of Man," 88, 255-260; compared with "Origin," 255; object, 255-256; reaction to —, 256; sexual selection, 257-258.

De Vries, Hugo, 254, 329; "Species and Varieties," 329.

Diderot, Denis, 95.

Discussion of 1830 (see also Cuvier and Geoffroy St. Hilaire), 43, 44, 109, 113, 118-120.

Disraeli, Benjamin, Lord Beaconsfield, 242.

Dorsey, George A., 5; — on Owen, 141; psychoanalyzing Darwin, 161; 194, 236, 260, 273-274, 373.

Draper, John W., 234-235.

Drummond, Henry, 88, 365-366; "Natural Law in the Spiritual World," 365; "Ascent of Man," 366.

Duncan, Carson S., 14.

"Dynamo," 29.

Eddington, Arthur Stanley, 5, 26, 373, 431-432.

Edinburgh Review, 219, 256, 260.

Emerson, Ralph Waldo, 15, 158.

"Essays and Reviews," 238-240.

Evelyn, John; "Sylva"; "Acetaria," 375-376.

Evolution, 21, 30, 36, 56, 63ff., 80, 85, 100, 105-109, 122-130; — reversed (degradation), 136; — according to Owen, 142; — according to Spencer, 150-151; —, General Doctrine, 152-155, 159, 245-246, 355, 358; Darwin's first interest in —, 170ff.; 252-254, 311-330, 343; superorganic evolution, 362. See also Part II and Part III. "Evolution" (preformation in the egg), 86-87, 95.

Fabre, Jean Henri, 396, 414.
Faraday, Michael, 11, 117, 373, 377-378; "Nature of Matter," note, 377; "Experimental Researches," 378; "Chemical Manipulation," 378; "Chemical History of a Candle," 378.
Fiske, John (Edmund Fiske Green), 25, 88, 365, 370; "Cosmic Philosophy," 367; "Excursions of an Evolutionist," 368; "Destiny of Man," 368; "A Century of Science," 369; — and Clifford, 384.
Fitzgerald, Edward, 123.
Fixity of Species, 39-40, 47, 64-65, 71, 102, 109, 113, 115, 119, 148, 159, 169, 213, 217-218.
Fontenelle, Bernard, 34, 419.
Forbes, Edward, 203, 282, 283.
Forbes, H. O., 402.
Foster, Sir Michael, quotation, 62, 286.
Fox, W. Darwin, 196-197, 201.

Galapagos Islands, 168, 171, 188, 205.
Galileo, Galilei, "Two New Sciences," 375, 418.
Galton, Francis, 255.
Geikie, Archibald, Sir, 390-392; "Story of a Boulder," "Glacial Drift," "Ancient Volcanoes of Great Britain," etc., 391.
Geikie, James, 390-392; "Great Ice Age and . . . Antiquity of Man," "Prehistoric Europe," etc., 391.
Genesis, 67, 123, 239, 307.
Geoffroy Saint-Hilaire, Etienne, 43, 101, 108; discussion of 1830, 113, 118-120; "Anatomical Philosophy," 117; "Etudes Progressives," 118; unity of composition, 116-117-118; balance or organs, 118; "Zoological Philosophy," 119; style, 120, 121; — and Chambers, 124, 129; — and Owen, 142, 148, 159, 188, 253-254.
Geographical distribution, 188, 199, 205; see *Wallace*.
Geology, 20, 34-42, 43-59, 80, 103, 131ff., 166, 178-182; the geological record, 224-225; 238, 308, 360, 391.
Glacial theory, 46, 57.
Gladstone, William Ewart, 305-308.
Glanvil, Joseph, quotation, 62.
Godman, John, 412.
Goethe, Johann Wolfgang von, 29, 39, 43-44, 93-97; "Metamorphoses of Plants," 94-95, 96; "Formation and Transformation" ("Bildung"), 96-97; "Intermaxillary Bone," 96-97, 118, 144, 294.
Grant, Robert Edmond, 289-290.
Gray, Asa, 199-200, 207, 220, 237, 251.
Gray, Thomas, 400.
Greenwood, George, 57, 327.

Haeckel, Ernst, 99, 286, 322; works, 328.
Haldane, John Beresford, 29.
Hardy, Thomas, 158.
Helvetius, Johann Friedrich, 63.
Henslow, John S., 162, 165-166, 172, 217, 220, 233, 235.
Herschel, (Frederick) William, Sir, 11, 80, 124.
Herschel, John, Sir, 163; "Preliminary Discourse," 164, 420; influence on Darwin, 165, 419-421, 426; "Catalogue of Stars," 419; "Treatise on Astronomy," etc., 420; "Familiar Lectures," 420; The Moon Hoax, 421.
Hicks, Philip Marshall, 7, 14-15.
Higgins, W. Mullinger, "The Entertaining Philosopher," etc., 379-380.
Homer, 177, 252, 294, 306.
Homology, 70, 95, 127, 142-146, 188-189.
Hooker, Joseph Dalton, Sir, 139, 159, 189, 197-198, 203; —'s "Botany of Antarctic Voyage"; "Flora of New Zealand," 213; 217, 224, 236, 311; with Sir James Ross, "Voyage of Discovery," 402.
Housden, C. E., 431.
Hudson, William Henry, 256; "Ornithology of Buenos Aires," 327-328, 408; — and Darwin," 328;

"Hind in Richmond Park," 395-396, 410; life and work, 408-412; "Purple Land," "Green Mansions," "A Shepherd's Life," 409; "Naturalist in La Plata," "Idle Days in Patagonia," "Afoot in England," "Book of a Naturalist," "A Crystal Age," "Argentine Ornithology," etc., 410; "Far Away and Long Ago," "Traveller in Little Things," 411.
Humboldt, Alexander von, Baron, "Personal Narrative of Travels," 162-163, 340, 402; influence on Darwin, 162-166, 167, 182; 237, 339-342; "Ancient Inhabitants of America," 340; "Aspects of Nature," 340; "Cosmos," 340-341; —'s omniscience, 339, 342; 373.
Hunter, John, 40, 114.
Hutton, James, ("Theory of the Earth"), 34-39, 57, 103, 327.
Huxley, Aldous, 28-29.
Huxley, Julian, 30.
Huxley, Thomas Henry, 22, 27, 36, 46; opinion of "Vestiges," 121; 147, 148, 158, 160, 186, 224, 373; — and Darwin, 217-220, 284; review of "Origin," 218-219; lecture at Royal Institution, 219; — at British Ass'n, 233-236; "Man's Place in Nature," 235, 242-244, 290; life and work, 281-310; studies and voyage, 282-283; "Anatomy of Medusæ," 282-283; marriage, 283; —'s lecturership, 283; professorships, 284; "Autobiography," 284, 295; literary faults, 284; "Aphis," "Brachiopoda," "Hydrozoa," 285; "Pyrosoma," "Invertebrata," "Crayfishes," "Birds and Dinosauria," "Amphibia," "Ceratodus," "Vertebrate Skull," etc., 286; — as a popularizer, 286, 289ff., 374-375; —'s original discoveries, 286-287; —'s style, 289-298, 388; clearness, 289-295; culture, 294; honesty, 290-295; 'Method and Results," 290; "Evolution and Ethics," 290; "Darwiniana," 291; "Science and Culture," 291; "Lay Sermons," 291; "American Addresses," 291; 'Science and Hebrew Tradition," 291, 304; "Science and Christian Tradition," 291, 304; "Collected Essays," 291; stylistic graces, 295-298; — as a debater, 296, 303-309; —'s philosophy, 298-302; educational theories, 302-303; controversies, 303-309, 322; — and Owen, Wilberforce, 303; —and Argyll, 304; "Scientific and Pseudo-scientific Realism," 305; — and Gladstone, 305-308, 311, 395; — and Comte, 345, 347.
Huygens, Christian, 419.

Inheritance of acquired characteristics, 106-107.
"International Catalogue of Scientific Literature," 16.
Irving, Washington, 63.

James, William, 261.
Jefferies, Richard, 404-408; naturalist, not scientist, 404-405; "Gamekeeper at Home," 405; "Amateur Poacher," "Open Air," "Nature Near London," "Life of the Fields," "Wood Magic," "Bevis," etc., 406-407; "Story of My Heart," "Amaryllis at the Fair," 407; —'s philosophy, 407-408.
Jenyns, Leonard (also known as Blomefield); — and Darwin, 178, 220.
"Journal of Researches" (Darwin), 170, 171, 174-177, 179, 402; style, 175ff., 194; — and Hooker, 197.
Judd, John W., 22.

Kellogg, Vernon, 329.
Kingsley, Charles, 46, 88, 220-221; 324ff., 382-383; "Scientific Lectures," 382; "Glaucus," "Water Babies," "Madam How and Lady Why," 383.
Kirwan, Richard, 39.
Knight, Charles, 51, 123, 380.
Knight, Francis A., "By Leafy Ways," 404.
Krutch, Joseph Wood, 158.

Lamarck, Jean Baptiste Pierre Antoine de Monet, Chevalier de, 11; 40; 43, 52; Lyell's refutation, 55, 86; 97, 100-109; his life, 100-101; classification, 102; "Hydrogeology," 103; "Organization of Living Bodies," 103; "Zoölogical Philosophy," 104-108; "Natural History of Animals without Backbones," 105, 108; inheritance of acquired characteristics, 106-107; other works, see notes pp. 101-102; Lamarckian factors in evolution, 106; 122, 124, 253, 272; — and Chambers, 124, 128, 129; — and Miller, 139; — and Owen, 148; — and Spencer, 150; 159, 160, 196, 218, 253.
Lankester, E. Ray, Sir, 286, 392; "Extinct Animals," "Science from an Easy Chair," 392.
Laplace, Pierre Simon, Marquis de, 122, 124.
Linnæus, (Carl von Linné), 65, 76, 77, 87, 89, 98, 116, 148, 208; "Systema Naturæ," 400.
Linnean Society, 147 note; 194, 208-214, 263, 282, 315.
Lockyer, Joseph Norman, Sir, 430.
Lowell, Percival, 373-374, 427-429; "Mars as the Abode of Life," 429; "The Solar System," 429; "Mars and its Canals," 429; 431.
Lubbock, John, Sir (Lord Avebury), 36, 202, 380, 389-390; "Prehistoric Times," 305, 389; "Ants, Bees, and Wasps," 389; "Flowers, Fruit, and Leaves," "The Beauties of Nature," etc., 390.
Lubbock, John William, Sir, 380.
Lucretius, Titus . . . Carus, 29; *"De Rerum Natura,"* 63.
Lyell, Sir Charles, 11, 34, 39; "Principles of Geology," 44ff.,-59; 126, 139, 154, 159, 160; — and Darwin, 168, 169, 188, 189, 197, 201, 217; — and Wallace, 205, 206-214; — *"per*verted," 220; "Manual of Geology," 220; "Antiquity of Man," 220, 240-242; 223-224, 228; style of writing, 241-242, 327, 390; see also "Principles of Geology."
Maeterlinck, Maurice, 414.
Malthus, Thomas Robert, 72, 86, 183-184, 210.
Mantell, Gideon Algernon, 50, 378-379; "Geology of the Southeast of England," "Medals of Creation," etc., 379.
Mars and its canals, 427-431.
Matthew, Patrick, 113.
Maxwell, Alexander, 419.
Mendel, Gregor, 255.
"Metamorphoses of Plants," 94-97.
Mill, John Stuart, 244, 342, 354, 356.
Miller, Hugh, 37, 130-140; "Scenes and Legends," 132; "Schools and Schoolmasters," 131; talent and personality, 130-133; "Old Red Sandstone," 132; — as a scientist, 132-133; — and Buckland, 133; —'s style, 134; "Footprints of the Creator," 135-136; "Testimony of the Rocks," 135, 137; —'s dualism, 136, 138-139; — and anti-geologists, 138; — and Owen, 141; tribute by Brown, 140, 238; "First Impressions of England," 402.
Millikan, Robert Andrews, 25.
Milman, Henry Hart, Dean ("History of the Jews"), 49.
Mivart, St. George Jackson, "Genesis of Species," 256, 327, 326-327; "The Cat," 327.
Montague, William P., note 26.
Morgan, C. Lloyd, "Emergent Evolution," 30.
Muir, John, 414.
Murchison, Sir Roderick Impey, 54-55-56, 57, 223.
Murray, John, 57, 216, 423.
Mutation, Saltation, etc., 111, 117, 254, 329.

Natural history essays and journals of travel, 394-415; general characteristics, 394-398.
Natural Selection, 21; Wells, 112-113; Matthew, 113; Darwin, 148, 153, 160, 183, 187-195, 201-202, 209-214, 216, 224, 229, 253-254; "survival of the fittest," 153, 253; sexual selection, 88, 257-258,

312; Wallace, 313, 317, 318-322.
Neff, Emery, 344-345.
Neo-Darwinism, 88, 272, 328, 329.
Neptunists, 38-39, 97.
Newman, John Henry (Cardinal), 308.
Newton, Isaac, Sir, 11, 49, 239, 258, 286, 416.

O'Brien, Fitz-James, 27.
Oken, Lorenz, 99-100, 118, 144, 286.
"Origin of Species," 22, 142, 187, 194, 216-232; sale, 216-217; reactions to —, 219-255; 236, 237, 249; compared with "Descent of Man," 255, 260, 284, 290, 317; influence on Spencer, 355.
Ornstein, Martha, "Scientific Societies," 14.
Osborn, Henry Fairfield, 22, 25, 99, 100, 115.
Owen, Richard, Sir, 141-149; —'s work and fame, 141; derivation, 142, 160, 178, 324; "Fossil Mammalia," 142-143; "On the Archetype," 143-147; "Nature of Limbs," 145-147; "Classification of Mammalia," 147-148; "Transmutation of Species," 148; — and Spencer, 149; 159-160; — and Darwin, 178, 188; review of "Origin," 219-220, 223; — at British Ass'n, 233-234, 242, 244; 303; "Anatomy of Vertebrates," 256, 324-325.
Oxford, 27, 232-237, 303.

Paley, William, 34, 35-36, 53, 89, 103, 106, 122.
Pearson, Karl, "The Grammar of Science," 370-371.
Philosophical Transactions, note 161, 285, 378.
Pickering, William H., 431.
Playfair, John, 38-39, 57, 327.
Plurality of worlds, 416-433.
Plutonists, 38-39, 45ff., 97.
Poe, Edgar Allan, 274.
"Poetry and Science" (I. A. Richards), 28.
"Poetry and Science and Other Essays in Prose" (Oliver Ellis), 28.
Popularized Science, 13, 23, 24, 164, 372, 393; "humanizing," 6, 7, 393; 395.
Positivism, 160, 308, 342-347.
"Principles of Geology" (Lyell), 44ff.; second volume, 55-56; its influence, 57ff.; revisions, 57-58; — and Darwin, 168-169; — and Hooker, 197, 242.
Proctor, Richard A., "Other Worlds than Ours," 322, 425, 427; 425-427; "Light Science for Leisure Hours," 425-426; "Half Hours with the Telescope," 426; "Essays on Astronomy," 426-427; 430.
Project Method, 432-433.
Proust, Marcel, 158.
Pusey, Edward Bouverie, "Unscience," 322-323.

Quarterly Review, 49, 164, 220, 222, 233, 235, 256.
Questionnaire, 14, 373-374, 435-439.

Raleigh, Sir Walter, quotation, 62.
Recapitulation, (Embryology), 85, 127, 189, 192-193, 219.
Rickert, Edith, 9.
Romanes, George John, 272, 328-329; "Mental Evolution," etc., 329.
Robinson, James Harvey, 6, 7.
Romanticism, 91, 93, 97, 121, 132, 341.
Romance, scientific, etc., 27-28.
Royal Institution, 145, 219, 284-285, 376.
Royal Society, 15, 56, 110, 186, 283, 285, 286, 378, 419.
Rudimentary or Vestigial Organs, 80, 96, 118, 189, 193, 225.
Rumford, Benjamin, Count, 376.
"R. U. R.," 29.

Schleiden, Matthias, and Schwann, Theodor, 99.
Sclater, Philip Sutley, 316.
Scrope, George Poulet, 49, 58.
Sedgwick, Adam, 50, 56, 166, 172, 221-222, 418.

Seward, Anna, 74, 76-77, 79, 90, 91.
Shakespeare, William, 22, 177, 179, 228, 258.
Shaw, George Bernard, 66, 97.
Slosson, Edwin Emery, 5, 14, 373.
Smith, William, 40, 114.
Society for the Diffusion of Useful Knowledge, 51, 123, 380-381.
Somerville, Mary Fairfax, 352-353; "Connexion of the Physical Sciences," 353; "Mechanism of the Heavens," 352.
South America, 168, 170, 186.
Spallanzani, Lazzaro, 40.
Species, 47, 55-56, 66, 70-71, 101-102, 106, 178, 180, 147, 169, 183; — of barnacles, 185-186; 188, 195, 196, 205-206, 208-214, 318, 326, 329.
Spencer, Herbert, 20; quotation, 62; — and Lamarck, 100, 160, 149-155, 367; —'s personality, 149; "Development Hypothesis," 149-151, 290; "Reciprocal Dependence," 151-152; generalization, 152, 153, 246, 355; synthetic philosophy, 152, 244, 353-365; "Progress," 152-153, 355; "Nebular Hypothesis," 154; "First Principles," 245-248, 357; "Principles of Biology," 247, 360-361; —'s style, 246, 363-364; Darwin's opinion, 247-248, 253; — and Argyll, 305; — and Comte, 342, 347, 358-360; General Doctrine of Evolution, 152-155, 242-246, 355, 358; "Principles of Psychology," 355, 361; "Classification of the Sciences," 358; "Transcendental Physiology," 152, 361; "Social Statics," 361; "Constitution of the Sun," 425; "Principles of Sociology," 362; "Principles of Ethics," 362; "Philosophy of Style," 363-364; Spencerian school, 149, 365.
Steno, Nicolas, 39.
Stephen, Leslie, 238, 351.
Stevenson, Robert Louis, 158.
Struggle for existence, 71, 117, 172, 187-188. See also Darwin, Wells, Matthew.
Syntheses or classifications of science, 18-20, 333-371.
Teleology, 17, 88, 95, 129, 145-146, 422-424, 427.
Tennyson, Alfred, 121-122.
Theology and science, 25, 26, 49, 67, 237. See Owen, Miller, Buffon, Huxley, Argyll, Wilberforce.
Thomson, John Arthur, 6, 373, 393.
Thoreau, Henry David, "Walden," etc., 7, 14, 413.
Thorndike, A. H., 15, note 18, 31.
Topsell, Edward, "Foure Footed Beestes," 122.
Transformism, 12, 99, 100, 104, 113, 115-116, 138, 150, 160, 290. See *Evolution.*
Treviranus, Gottfried Reinhold, 97-99.
Tyndall, John, 154, 285, 373, 383-389, 426; — the materialist, 385, 387; style, 385, 386-388; "Glaciers," "Forms of Water," 385; "Heat as a Mode of Motion," 386; "Use and Limit of the Imagination in Science," 386-388; "Light and Electricity," "Advancement of Science," etc., 388; "Fragments of Science," etc., 389, 395.

Uniformitarianism, 45-50, 169.

Verne, Jules, 27.
"Vestiges of the Natural History of Creation," 121-130; Huxley's and Darwin's opinion, 121; an outline of science, 123-124; quotations, 125-127; style, 125-126, 134, 160, 190, 218, 223, 381.
Victorian Period and Standards, 16-17-18, 47-48, 146, 206, 278, 291, 296, 305, 376, 378, 392, 400, 408.
von Baer, Karl Emil, 154, 158, 237, 360.
"Voyage of the *Beagle*" (see "Journal of Researches").

Walker, Hugh, 15, 133, 238, 307.
Wallace, Alfred Russel, note 17; — and Chambers, 129, 148; — and Darwin, 205-214, 317; — in Malay Archipelago, 205; "Law . . . Introduction of New Species," 205; "Tendency of Spe-

cies to Form Varieties," 208-214; style, 210-211, 243, 254, 255; review of "Expression of Emotions," 260, 261; travels, 311, 314; "Zoölogical Geography of Malay Archipelago," 315; "Wallace's Line," 315; literary style, 315-317, 319, 320-321; speed and variety, 316-317; "Malay Archipelago," 317; "Contributions to Natural Selection," 317; "Darwinism," 319-321; "Geographical Distribution of Animals," 318-319; social, economic, spiritualistic works, 321; "Autobiography," 321; "Island Life," 322; "Wonderful Century," 322; "Man's Place in the Universe," 322, 429-431; "Is Mars Habitable?" 322, 429; "The World of Life," 322; death, 322; 328, 373; "Travels on the Amazon," 402.
Walton, Izaak, "Compleat Angler," 398.
Waterton, Charles, 176; "Wanderings," note 176, 400-402.
Weismann, August, 98, 255, 328.
Wells, Henry W., 28.
Wells, H. G., 6, 27.
Wells, William Charles, 110-113; Natural Selection, 113; "Two Essays," etc., 111; style, 111, 129.
Werner, Abraham Gottlob, 38, 39, 93.
Westminster Review, 354.
Whewell, William, — and Lyell, 56, 166; — and Darwin, 222; life and work, 347-352; "Mineralogical Classification," 348; "Treatise on Mechanics," 348; "Elements of Morality," 348; "Astronomy and General Physics," 348; "History of the Inductive Sciences," 349; "Philosophy of the Inductive Sciences," 350-351, 353; "Plurality of Worlds," 422; "A Dialogue on the Plurality of Worlds," 424, 425.
White, Andrew Dickson, "Warfare of Science with Theology," 120, 322.
White, Gilbert, "Natural History of Selborne," 399-400, 404.
Wickenden, William E. (Society for the Promotion of Engineering Education—"What Does an Engineer Do?" and "An Engineer's Valuation of English"), 32.
Wilberforce, Samuel (Bishop of Oxford), 27, 220; review in *Quarterly*, 233; — at British Ass'n, 233, 235-236, 303.
Wilkins, John, Bishop of Chester, 221; "Discovery of a New World . . . in the Moon," 417-418.
"Wings Over Europe," 29.
Wollaston, William H., 222.
"The Wonders of the World" (by Charles Sears), 379.
Wordsworth, William, 28, 91, 132, 166.
"World We Live In," 29.

Zola, Emile, 27, 48.

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